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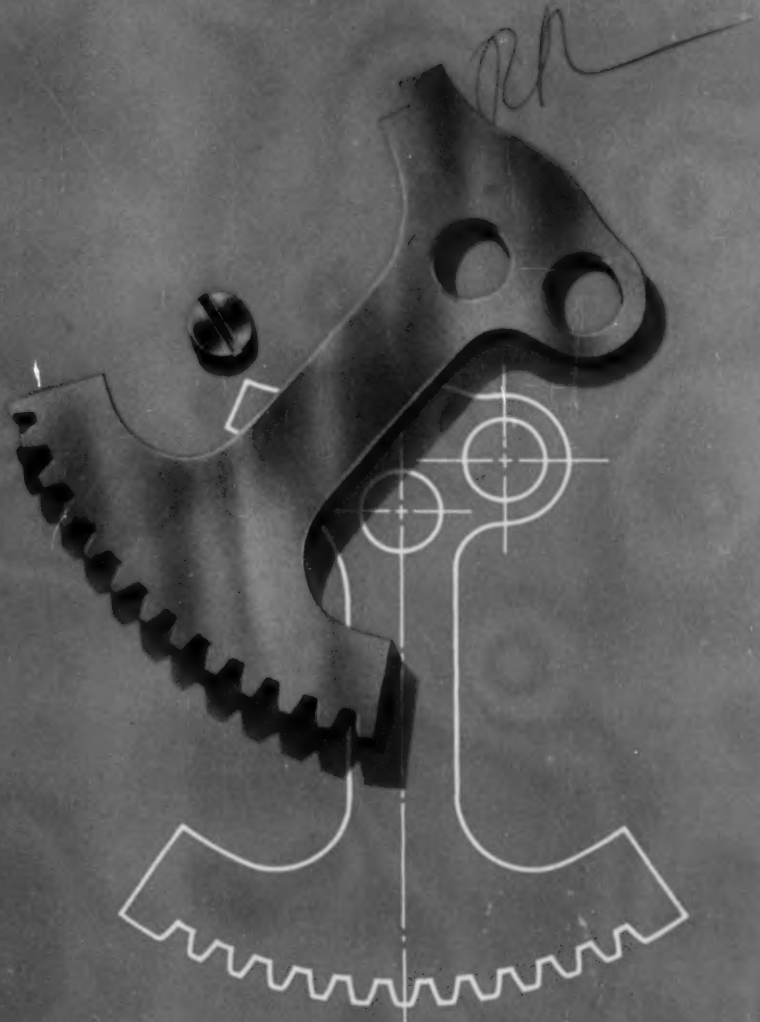
AUTOMATION

NOVEMBER 1955



PRODUCT AND PROCESS

Design for Automation

The Magazine of Automatic Operations

- **Producing Circuits for Electronics**
- **Automation in Banking**
- **Automatic Ordnance Manufacturing**
- **Vibratory Feeding of Parts**

CONTENTS—PAGE 3

A PENTON PUBLICATION

WEAN "AUTOMATED" TRANS-CAR LINE SOLVES HEAVY PARTS HANDLING PROBLEM

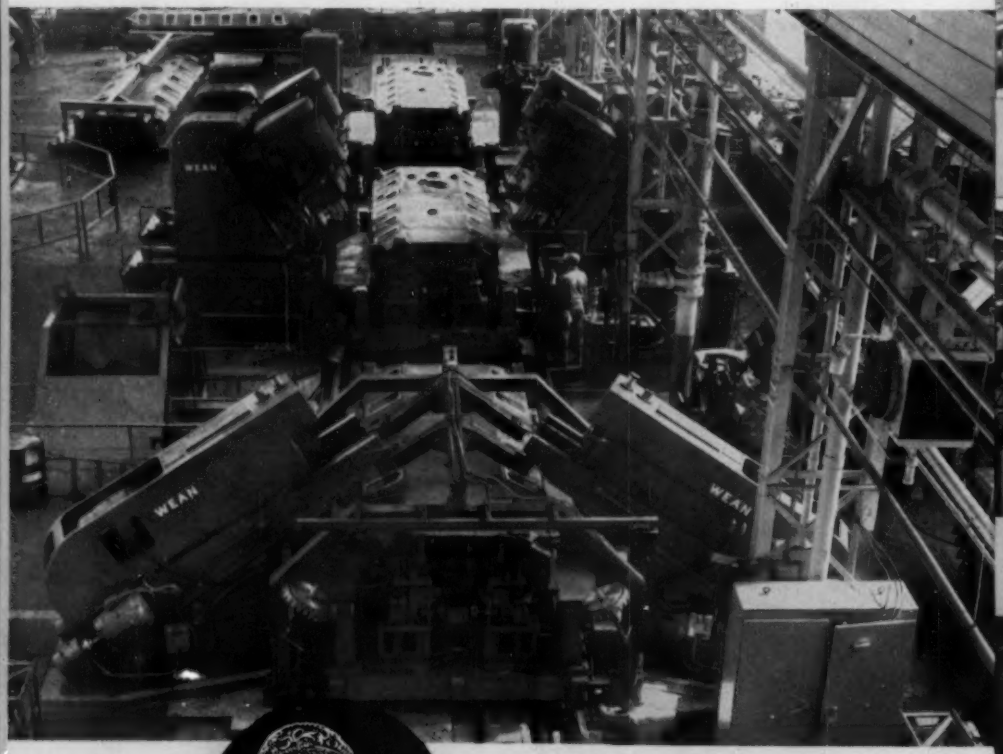
Unique system carries bulky sections through entire machining operation

The Massey-Harris Co. is used to handling and precision working large machine components. Thus, when they accepted the contract to produce combat vehicle hulls for the Army they immediately got in touch with Wean Equipment engineers.

A team of Wean Equipment engineers working with a similar group from Massey-Harris soon vetoed the possibility of using standard machine tools on a cost basis. It was decided a complete line, especially built to do the job, was the only practical answer.

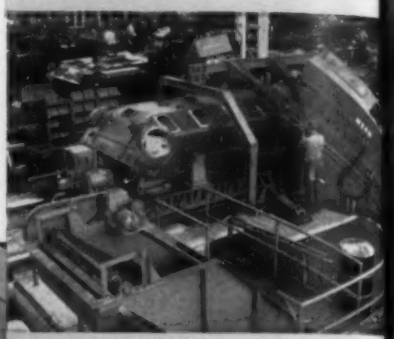
In eight months' time, Wean Equipment developed and built the now famous trans-car line. The line is composed of three stations: milling, drilling, and boring. The unusual feature is the car that operates on a set of tracks, running between stations, and eliminates all handling of the bulky, heavy hull.

If special "automated" machinery is what you're looking for, call in a Wean Equipment man today. He represents probably the widest experience in specialized machinery to be found anywhere. Like Massey-Harris, you'll find Wean the surest, most inexpensive way to soundly engineered, result-getting machinery.

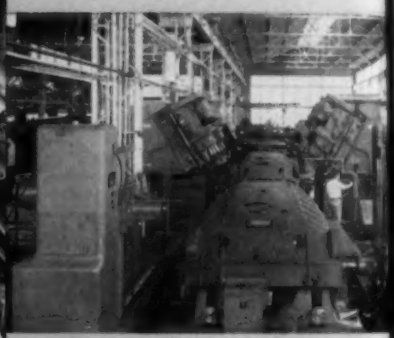


Over-all view of Wean Line that effected tremendous savings in producing giant hulls.

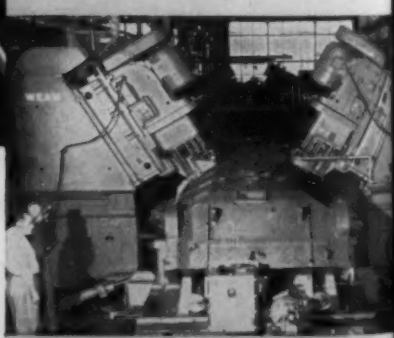
Unique trans-car that carries hull f station to station.



Milling operation. Dry cutting w carbide cutters. Air jets remove ch



Drilling operation. Beneath the floo coolant system with magnetic ch separator.



Boring operation. Drills, taps a reamers are of high speed steel. operations are automatic.

Wean

EQUIPMENT CORPORATION
CLEVELAND, OHIO

NOVEMBER, 1955
Vol. 2—No. 11

AUTOMATION

THE MAGAZINE OF AUTOMATIC OPERATIONS

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REGULAR DEPARTMENTS

Automation Outlook, 4

Automation News, 10

Detroit Dateline, 29

New Equipment, 83

New Components, 91

Patents, 100

New Literature, 102

Abstracts, 108

Editorial Index, 118

New Books, 120

A Little Tailoring, 33

EDITORIAL—details of product design hold secrets to economical and practical automatic production.

Designing for Automation, 34

ROGER W. BOLZ—basic factors and rules to consider in assessing product and process design and the automatic system.

Pallet Carrier Sequences Impregnating System, 44

REMOTE CONTROL—car with a traversing carriage loads, discharges and transfers racks through several stages.

Transistors in Automation, 48

C. B. IRWIN, JR.—kinds and basic characteristics of component whose reliability insures role for electronic control.

Continuous Registration, 54

A. I. BESSONNY—electronic control and differential gear transmission provide corrections to maintain register.

Automation is an Asset in Banking, 57

RAY R. EPPERT—volume of paperwork and shortages of labor bring need for automation of clerical procedures.

Automation in Ordnance, 62

W. J. COLGAN—quantity, standardization and safety in ammunition loading point out desirability of automation.

Line Produces Bundled Tubing, 66

TAPING OPERATION—number of tubes to be packed is clamped into least perimeter while applying heads wrap for shipment.

Vibratory Feeding of Parts, 67

GEORGE H. KENDALL AND JERRY A. HOST—bowl type units accomplish storage, orientation, and movement of parts.

Producing Circuits, 71

P. L. ANDERSON AND J. A. ZAGUSTA—die-blanking method makes "printed circuits" for mechanized electronics assembly.

Better Static Sealing, 75

DESIGN DEVELOPMENTS—research in the aircraft industry led to successful techniques of confining hydraulic fluids.

Cell Type Plating, 77

CONTINUOUS PRODUCTION—quality advantages of former manual method obtained by automated handling system.

automation outlook

OTHER OFFICE TOOLS

". . . no thinking person today expects electronics or anything else to wipe out all our data processing problems. Such is the nature of the clerical operation that the only panacea for any company would be a padlock on the front door. But it would be equally unrealistic to believe that the only major gains can come via electronic equipment of some kind—that no other action is really worth the effort . . ."—*Ray R. Eppert, executive vice president, Burroughs Corp.* *See Page 57.*

HANDLING PROBLEMS

". . . handling the product is one of the major considerations in the engineering effort required to set up automated production facilities. Often, as much thinking must go into the problems of getting the parts into and out of the machines as is required to design the automatic controls that regulate the continuous cycles of the equipment . . ."—*George H. Kendall and Jerry A. Host, consulting mechanical engineers.* *See Page 67.*

IT WOULD NOT PAY

". . . if the only object of such investment were to eliminate the operators in a process plant, it is almost certain that it would not pay. It is very doubtful whether the personnel would be reduced at all. However, if one resorts to the cybernetic principle with the object of increasing the quality of the product, of eliminating the cost of blending and additives and the attendant storage facilities, of increasing the yield from a given quantity of materials, of reducing the energy required to produce a given quantity of product, then the picure looks altogether different . . ." —*A. H. Kuhnel, assistant manager, Special Devices Division, The Austin Company.*

IMPORTANT CONSIDERATION

". . . recent trend is toward the inclusion of electronic controls in certain types of machine tools . . . However, many of these controls and automatic devices are sources of radio interference to electronic equipments and systems, and should be made to conform with existing radio-interference reduction requirements These controls may in turn be affected by other sources of interference. Some of these electronic control systems create as much radio-frequency power as a small radio transmitter, and if this radio-frequency power is not confined to the proper places within the machine many communications may be endangered . . . Instances of radio interference to radio comunications are the subject of many complaints to the Federal Communications Commission. Engineering examinations of many of these complaints reveal that radiations from many items can be used as targets for guided missiles. They can jam air-to-ground and ground-to-ship communications and thereby render them useless. They can reveal the location of electrical and electronic equipment. They can cause mistakes in electronic computers . . ."—*L. W. Thomas, radio interference consultant, Bureau of Ships, Navy Department.*

NOTHING NEW

". . . actually, the application of automatic control devices in industry has been underway for some time with no dire results. On the steel industry's tinning and galvanizing lines, which apply a thin coat of tin or zinc in a continuous process, radiation mechanisms already are in use which measure precisely the thickness of the coating; photoelectric cells detect minute pinholes in tinplate and automatically reject sheets which contain them. Sensitive heat measuring instruments on open hearth furnaces record temperatures on remote control panels and electric eyes tell when a "heat" is ready to be tapped. On rolling mills, electronic and radiation devices guide the rapidly moving strip of steel and continuously record its thickness. Such installations do temporarily displace some employees. They likewise serve to increase output and improve quality, with the inevitable result that more products are sold and more men needed to turn them out. . ."—*Steelways.*

AUTOMATION

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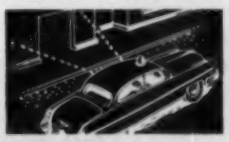

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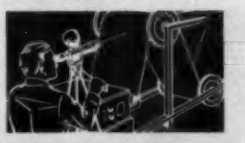

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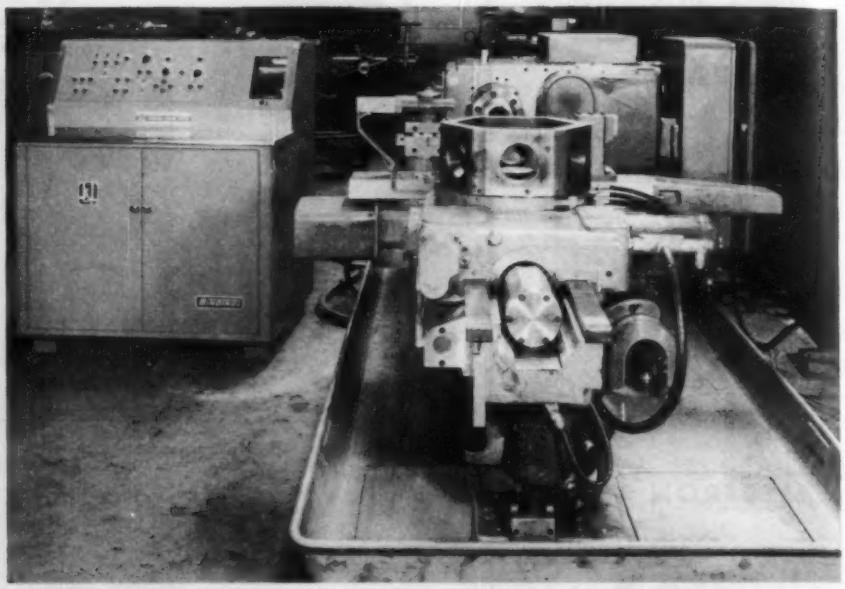
AUTOMATION news

Today's events and developments in the field of automation

Tape Control System For Machine Tools

PUNCHED tape control system designed for automatic operation of machine tools, valves and other industrial equipment has been developed by Barnes Engineering Co. The special computer utilized in the Binotrol system is characterized by the scarcity of electronic components. Commercially available telephone type relays are mainly used in the electrical circuits. The special plastic tape, 5 inches wide, used in the system provides for punching of 32 controlling holes. The actual number of controlling signals possible are much greater than 32 through the use of a binary code and special values which can be assigned channels for particular applications. For example, in an application of the control to a Jones and Lamson turret lathe, 15 digits provide for measure in increments of 0.001 inch from 0.001 inch to 32.767 inches. Starting from the left, each hole position represents a value double the preceding hole i.e., 0.001, 0.002, 0.004 to 16.384 inches. A desired signal is obtained by punching a series of holes in the tape such that the total represents the desired figure.



SPECIAL Jones and Lamson Machine Co. turret lathe adapted for automatic tape control has no handwheels. Control console at left contains necessary equipment for automatic control and pushbuttons for manual control during setup.

TAPE control system of Barnes Engineering Co. was developed by D. M. Frothingham. He stands next to the tape reader and holds a sample of the 5 inch wide tape used in the control.

On this particular turret lathe application, the Binotrol controls 16 spindle speeds, turret indexing, cross slide indexing, coolant, hood position, chuck and bar feed. The use of the automatic control in a turret lathe is directly aimed at short repetitive runs, and as such involves a new concept of the value of automatic controls to machine tool applications.

With the tool requirements worked out ahead of time and perhaps stored for future use, an unskilled operator can take the prearranged tool scheme and punched tape and very easily operate a turret lathe with a minimum of scrap and maximum of ease. The tape alone could provide for a means of duplicating complicated setups. To provide for repetitive operations the tape closes on itself and does not have to be reversed to arrive at the starting point.

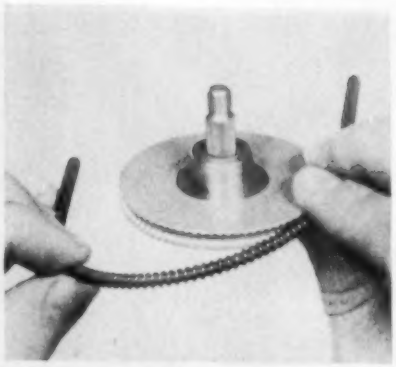
FORMATION of a new Instrument Services Division to fulfill demands for engineering facilities outside the normal range of company activities has been announced by Panellit, Inc. **Neil M. Blair** has been appointed manager of the new division which will provide consulting and installation services in the field of instrumentation and

automation. Included will be overall instrumentation studies and surveys, control system design and comprehensive project supervision. The new Panellit division will also handle complete installation of instrument and control equipment including inspection, calibration, check-out and plant start-up.

Automatic Circuit Tester

ELECTRIC circuit tester developed by Bogue Electric Mfg. Co. is capable of testing automatically several hundred electric circuits in a few seconds. Testers already in service at airframe plants, air bases and maintenance centers are being used to check out 100 circuits in only 8 seconds. The Bogue Nacelle Tester is a Wheatstone bridge device which automatically selects and compares circuit characteristics with known preset standards. Connection with aircraft circuits is made through quick disconnect plugs and cables. Once started, the tester examines each circuit individually and steps automatically from one circuit to another until the tests have been completed. In the event a circuit is faulty or does not closely match the known standard comparison circuit, the tester stops, sounds an alarm and identifies the faulty circuit. The tester can then be restarted to complete the tests. Meters are also provided for measuring the characteristics of each circuit so that the nature of the trouble in faulty circuits may be determined. In addition, switches are provided on the front panel of the tester for actuating motors and other electrical devices (including reversible propellors) on the plane being checked. Commercial and military users of the Bogue Nacelle Tester report considerable savings in manpower over manual circuit testing. They also report that fewer failures are experienced on planes checked out with the automatic tester because of the more accurate machine made tests.

DESCRIBED as the most highly automatic of any of the company's plants, new Westinghouse Electric Corp. manufacturing plant will be devoted to the manufacture of semi-conductor devices such as transistors, power rectifiers, high frequency detectors, and photocells.



FLEXIBLE rock has been developed by Teleflex Inc., manufacturer of mechanical remote controls. Contro's feature a special push-pull cable with a helical outer wrap which provides teeth to engage hobbed wheels placed wherever it is desired to rotate a shaft through a full revolution or more.

Bruce D. Henderson, Westinghouse vice president stated, "The semi-conductor devices that we will produce in the new plant are the result of a demand for greater automation in the nation's factories and requirements of the rapidly growing TV and radio industry. Automatic manufacturing equipment is needed in the plant because human hands cannot come in contact with the special materials used in the manufacture of semi-conductor devices without contaminating such materials." The plant should be completed by the end of 1955.

Look to Small Businesses For Automation Volume Market

AMERICA'S small businesses, not its industrial giants, will provide the large volume market for automation equipment in the future, **Paul B. Wishart,** president of Minneapolis-Honeywell Regulator Co. predicted recently. The number of firms producing automation equipment is growing; they are interested in volume and this market lies among plants with less than 1000 employees. The natural tendency, therefore, will be for automation equipment makers to design their wares, insofar as possible, to fit the needs of these more numerous small businesses. "My guess is," Wishart said, "that we will be astonished to look back ten years from now and see how much automation has resulted from the offering in the market place of standardized automation equipment, developed to meet the common denominator requirements of hundreds of thousands of small

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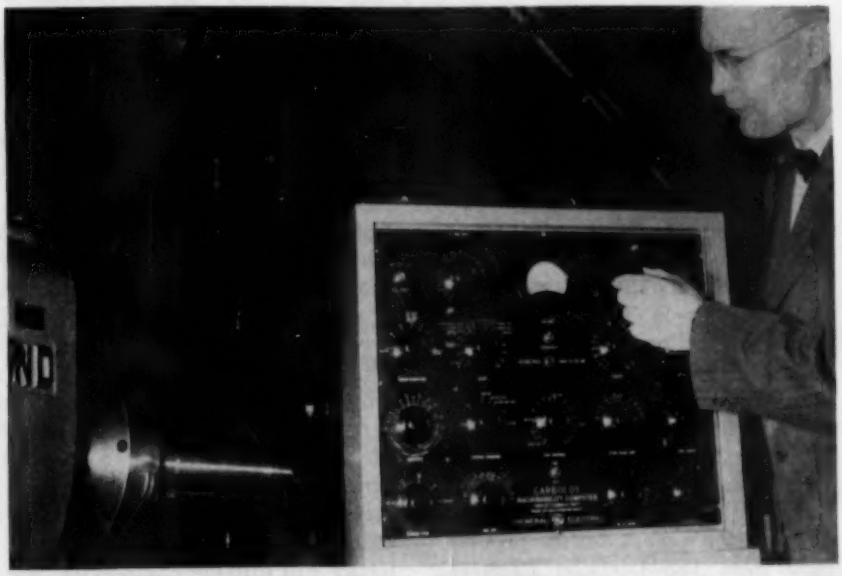


ELECTRONIC machinability computer developed by Carboloy Dept. of General Electric Co. will solve machining problems for the tool engineer in a few minutes which normally might take him several hours to solve. The new device will enable a methods and service man to determine quickly whether or not he is using a correct set of conditions for machining a current job; help him arrive at a proper set of conditions for setting up a new machining operation. It will consider 14 operational variables in machining, such as grade of carbide, speed, feed, depth of cut, tool life, alloy, and material hardness.

and medium-size companies.

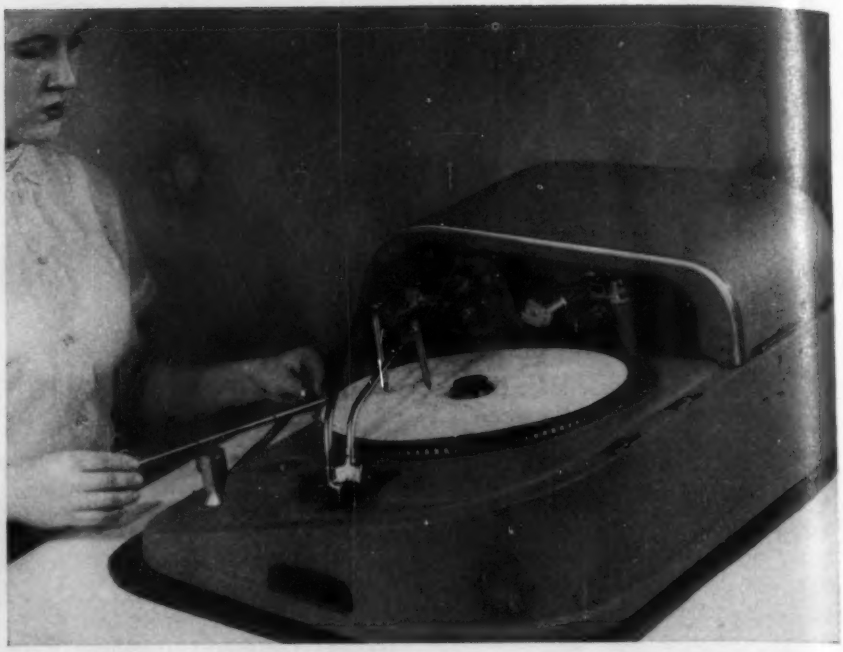
"I am not saying that automation equipment will be in the class of the shelf item," he added. "But I am sure that this logical interest in the broad rather than the narrow market will ease the load on many a small company which wants to benefit from a certain amount of automation but cannot afford the cost of designing and tailor-making all the necessary equipment.

"Small business faces two alternatives. The first is to be caught flat-footed, forced to fight rearguard actions, attempting to compensate for or counter new competitive conditions. The second is to anticipate, through careful study of what is going on in the economy and in the particular industry, and to plan a realistic course, thereby gaining advantage of early action and having the best possible chance of minimizing likely competitive pressures."

He pointed out that the small, specialized company often has definite advantages over the large company in low-volume and short production runs, in lower overhead and greater operating flexibility, in more direct and enthusiastic supervision of personnel, in more imaginative thinking in its specialized field, and in quicker acceptance within the company of original ideas and product improvements.

SUBSIDIARY of Librascope, Inc., the Minnesota Electronics Corp., has moved its entire operation from St. Paul, Minnesota to Burbank, California. Making the move to the West Coast with Minnesota Electronics is a staff of highly trained electronics engineers with considerable background in the complex field of digital computing techniques. Plans call for continuation and expansion of the Corporation's work on its proprietary item, the Decision Element. The company is developing a line of digital computer components utilizing a new decision element system with considerably greater logical flexibility, which will be of value in both military and industrial applications.

In addition, Librascope, Inc. has announced the completion of a new building in Santa Ana, California, to house its Mecca Division. Commercial products, including a line of automatic food processing machinery, will be manufactured at the new plant.



INTEGRATOR which mechanically computes the metered volume of gases, steam or liquids from orifice meter charts is a development of Rockwell Mfg. Co. Unit is designed to eliminate tedious calculations in computing volumes in gas, oil and other process industries. The electrically operated integrator features a counter setback assembly operating from the main calibration post that enables the operator to run practically all ranges of charts at any base pressure.

Servos for England

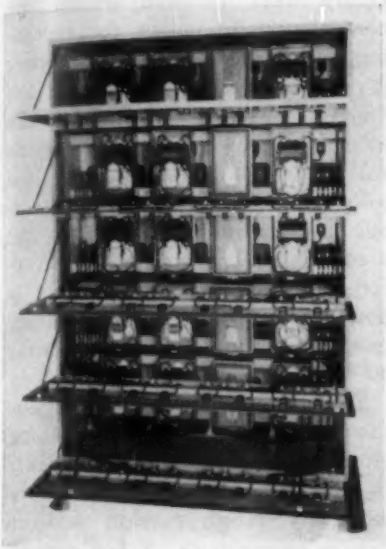
FORMED to design, develop and manufacture synchro and servo mechanisms in England is Ketay Ltd. **Morris Ketay,** President of Norden-Ketay, and **A. G. Clark,** chairman and managing director of Plessey, have announced that arrangements have been made to manufacture a complete range of sizes and types of these components for the European market. Plessey, the largest electronic and aeronautical component manufacturer in Europe, will furnish manufacturing facilities. Norden-Ketay will provide engineering, design and manufacturing information.

In making the announcement, Ketay and Clark stated: "Ketay Ltd. will serve Europe's need for high precision synchro and servo mechanisms for commercial and military applications including aircraft and marine instrumentation, computers, and automatic control systems. It is our belief that the European market for these components has unusual potential."

BOARD of directors of The Hydraulic Press Mfg. Co. have elected **John C. Coonley** president and member of the board. In assuming the presidency, Coonley fills a vacancy created last April. He brings to Hydraulic Press an ex-

tensive background in the metalworking and manufacturing industries. Until January of this year, Coonley was general manager of

the valve division of A.C.F. Industries, a position which he assumed in 1950. He was assistant works manager of the Heald Machine Co. from 1941 until 1950, and served as assistant to the president of the Lucas Machine Tool Company during 1940 and 1941. Prior to this he was associated with the Walworth Co., Inc., in various positions.

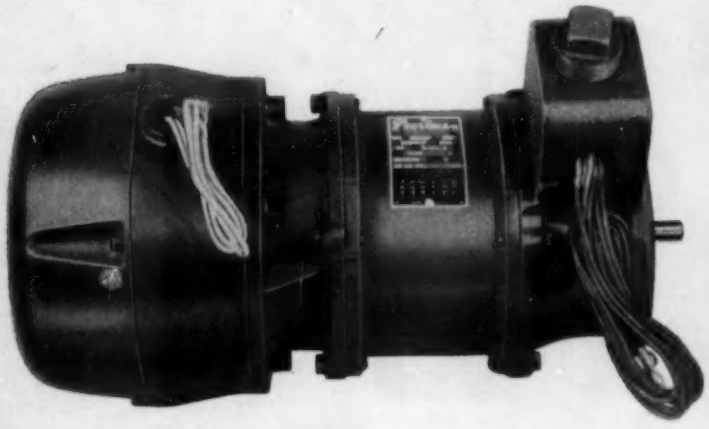


TIMER control panel manufactured by Eagle Signal Corp. enables Westinghouse to check the entire service life of appliances in just a few months. Toasters, coffee-makers, hot-plates, flat-irons and other Westinghouse appliances are plugged into sockets on the reverse side of the panel. Timers open and close circuits at pre-determined intervals, turning appliances on for the length of time they're in use under normal service conditions. Forty Eagle Microflex timers are wired to contactors located inside the cabinet. Newly engineered products are tested on the timing control panel to establish which designs give the most efficient performance and longest life at the lowest cost. The panel is also utilized to spot-check production off the lines.

Power Conveyor System For Army Field Use

OVERLAND conveyor system for transporting military cargo has been developed by Hewitt-Robins Inc. for the U. S. Army Transportation Corps. The first projected use for the new carrier is in port areas to move cargo from unloading docks to storage or dispersal points one to ten miles inland. It is believed the conveyor system can clear ports faster and more

where Special Requirements dictate Motor Construction



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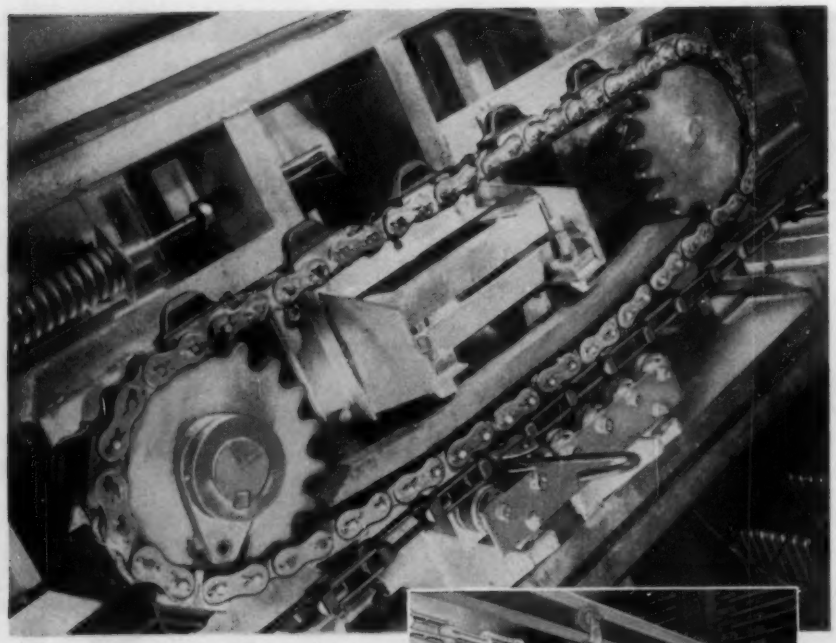

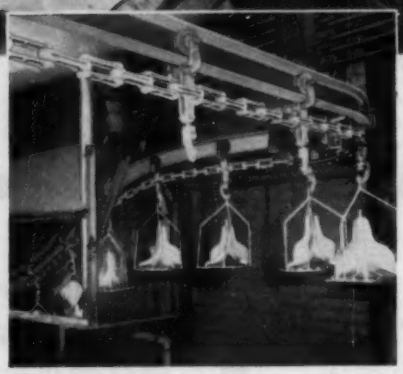

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Before you order any type of conveyor write us. We'll be glad to submit an estimate. In many cases we will be low. But low — or not — you can be sure your A-F Engineered Conveyor System will be right!

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THE ALVEY-FERGUSON CO., 175 Disney St., **CINCINNATI 9, OHIO** and Azusa, California

economically and with less manpower than has been used in the past to accomplish this task.

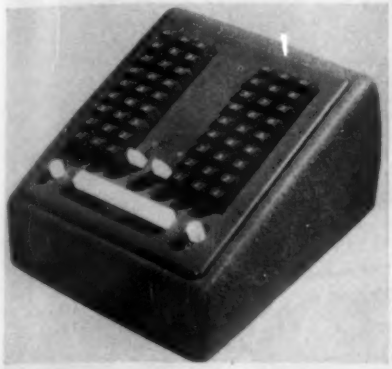
A wide variety of equipment and supplies can be transported such as drums of fuel, or palletized general cargo including ammunition, engines, food, medical supplies and clothing in unit loads as great as 3000 pounds each. Maximum capacity of the system is 270 tons per hour. The system includes main line and branch line conveyors with means for switching cargo from one to the other while in transit. In transit, the loads are carried on steel carriers mounted on small wheels which run on tracks. These carriers are joined together to form a continuous line resembling in appearance a caterpillar track on a tank tractor. Each flight of conveyor is powered by a standard military gasoline engine of approximately 30 hp.

The conveyor is made in sections that can be easily transported and stored and can be set up quickly in the field. It will operate over relatively rough terrain and up grades as steep as 27 per cent as compared with a maximum grade of about 9 per cent for trucks and 3 per cent for narrow gage railways. It can follow a straight path or be curved to avoid obstacles.

Military advantages of the conveyor over other methods of moving cargo from port areas to interior locations include the following: Can operate at full efficiency in fog, mud, dust, darkness and other conditions restrictive or hazardous to other types of surface transportation; does not require back haul and thus eliminates confusion of two-way traffic; and requires little site preparation—one pass of a bulldozer would be enough in most cases to clear a path.

ANALOGUE computing center has been established by Dian Laboratories, Inc. The new company is affiliated with Mid-Century Instrumatic Corp. The computing services are available to government and industry on a rental basis. Geared for round-the-clock operation in the solution of problems,

Dian is engaged in the design of simulators, trainers and special-purpose computers, and is a consultant to management in the introduction of automation in business and industrial applications. Its staff is headed by **Dr. Stanley Fifer**, former head of Navy project Cyclone and member of the technical staff of Hughes Aircraft Co.



MANUALLY operated decimal keyboard activates an X-Y plotter by supplying excitation for the X and Y input transducers. Pressing the plot bar on the keyboard actuates relays which permit motors in a X-Y recorder to drive the pen to the correct position on the chart. Circuits in the keyboard prevent the pen from marking the chart until the motors have positioned it in exact correspondence to the numerical value of the depressed switch keys. When the servos in the plotter reach the null, they cause a thyratron in the keyboard to fire, thereby triggering the pen-actuating mechanism in the plotter. A variety of contact configurations are available which make possible the manual feeding of decimal or binary coded decimal input. The new unit was developed by Librascope, Inc.

Refined Control of Crude Oil

AUTOMATIC control system to regulate the flow of crude oil through a key segment of the 1770-mile Interprovincial Pipe Line system has been completed by the Minneapolis - Honeywell Regulator Co. The system, stretching from the oil fields of Alberta to the refineries in Ontario, is the world's longest crude oil pipe line. The pneumatic-electronic control system was installed in a new pumping station and is part of an expansion program which has increased the capacity of the system from 178,000 barrels daily to 217,000.

The control system for the new station is designed to synchronize its pumping rate with the opera-

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Insures dependable operation and simplified control circuits

Designed with a sealed dial that covers the elapsed time indicator, the Cycl-Flex Timer permits direct mounting to machine panels that are exposed to oil and dust. Timer switches control four load circuits. Interlocking contacts provided without the use of auxiliary relays. Synchronous motor drive insures accurate timing.

The Cycl-Flex is one of the Eagle family of timers designed to fit into every industrial time control need. Eagle sales engineers, located in 30 principal cities, will analyze your timing applications without obligation.

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tion of the other stations on the pipe line. A master pneumatic controller monitors and regulates incoming suction and outgoing pressures. Tied into the controller are individual controls for each of the station's diesel engines. These controls can automatically speed up or slow down the speed of each engine to regulate the flow of crude oil. Built into the control system are a variety of protective instruments which can instantaneously shut down the station when required, or can signal abnormalities in pressures or engine operation. A master 20-foot control panel centralizes supervision of the station operation.

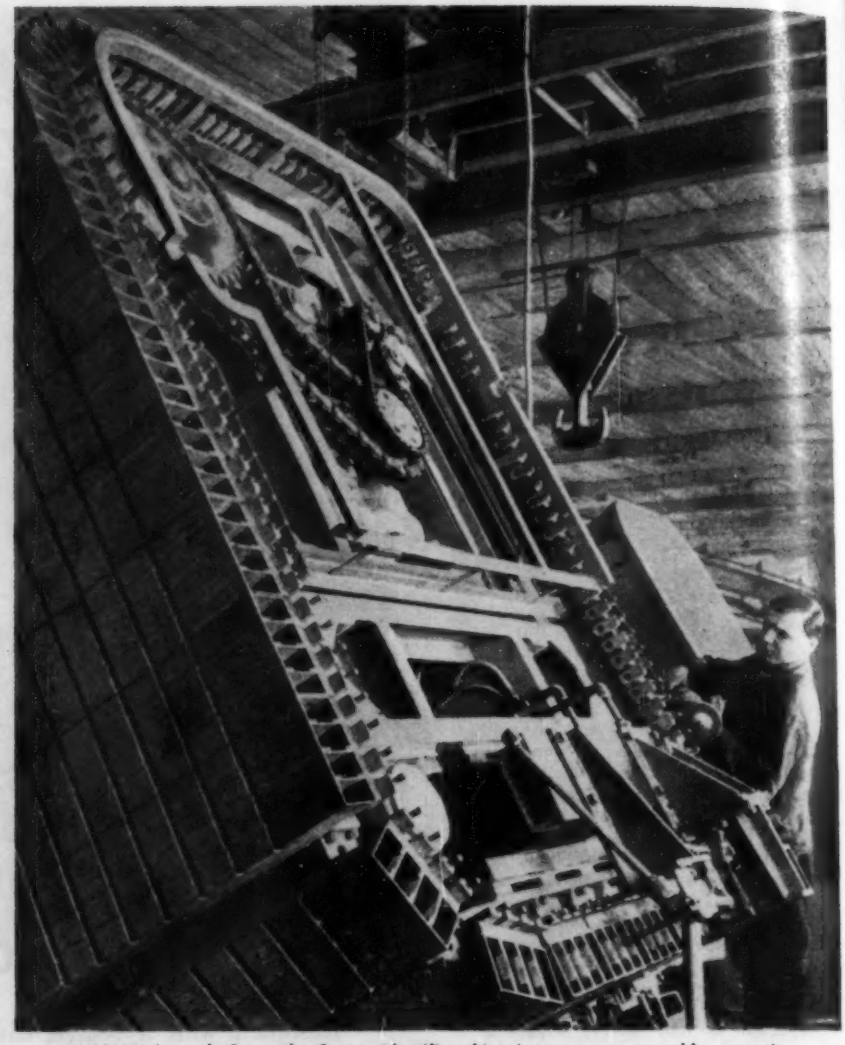
Increased Use of Automation A Major Russian Goal

By Charles L. Adams

RUSSIA is stepping up its drive for industrial modernization as Soviet cold war strategy switches increasingly toward use of economic rather than military weapons. Automation has been given an important role in the USSR's new program for overtaking and surpassing the West in productive capacity. All Soviet ministries have been ordered to introduce "advanced technology" in their plants as fast as possible; and some officials accused of impeding automation have been "fired."

Top Russian political leaders and scientists flatly contradict their own propaganda claims that the USSR already leads the world in automation development. They admit that the United States is still well ahead in this field and that some European countries, including satellite East Germany and Czechoslovakia, are using more modern technology than many Russian factories.

In a recent speech **Premier Nikolai Bulganin** charged that "automation processes are being introduced much too slowly." He added that the proportion of high-production machine tools in Soviet industry is declining. "We have," he declared, "many plants that are still turning out machinery inferior to that made abroad. We must remember Lenin's teachings that only application of the latest discoveries of science and technology can guarantee the rapid growth of labor productivity, which is, in the final analysis, the most important factor in the victory of the new (Communist) system."

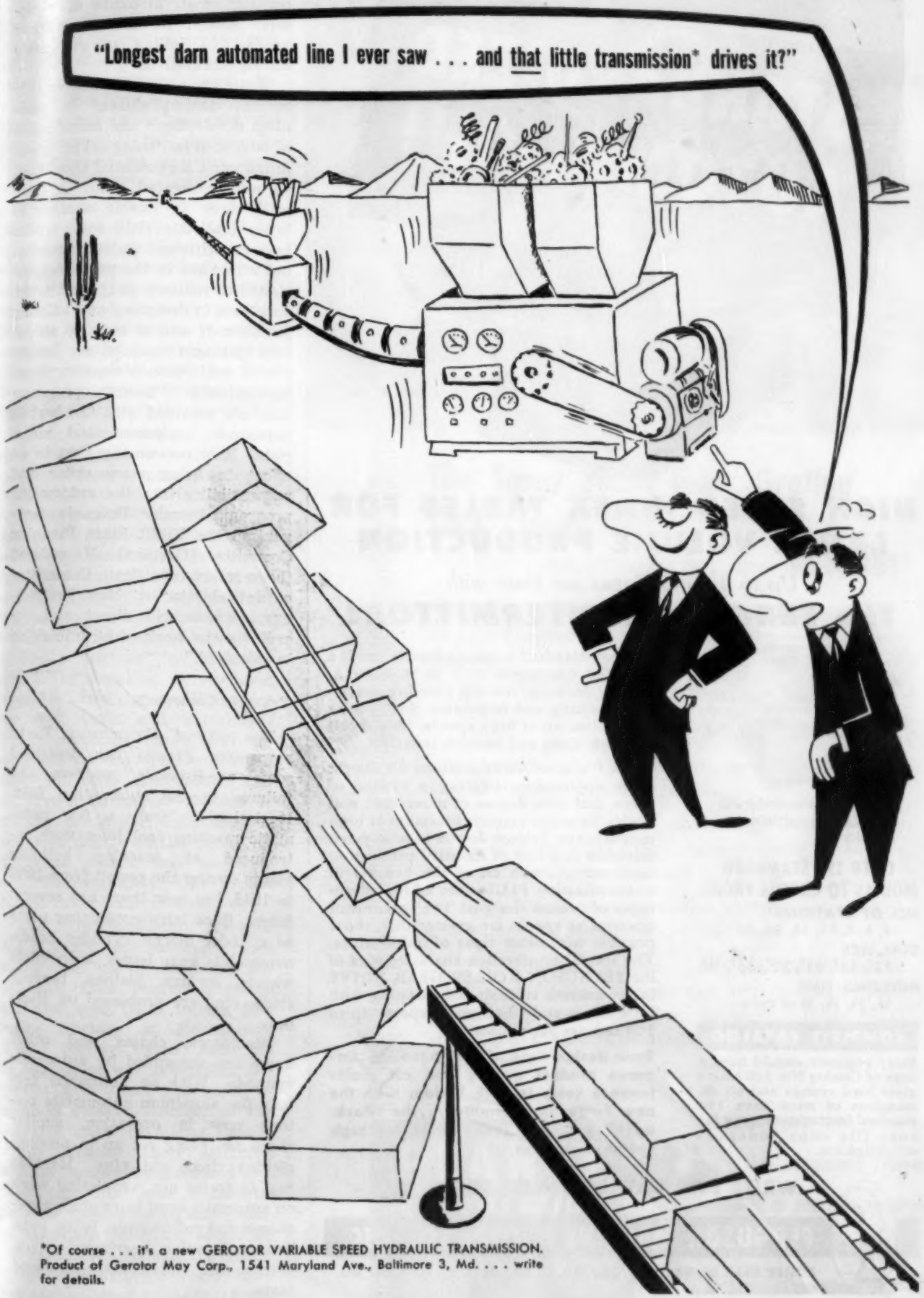


RUSSIAN journal, *Sovyetsky Soyuz*, identifies this picture as an assembly operation on a "magazine"—one of the elaborate units that forms automatic production lines for a ball bearing works. The attention of the Russian political leaders has been focused on automation as a means of attaining increased production.

Bulganin said that such progressive production methods as assembly lines, automatic and semiautomatic welding, fast metal cutting and heating by means of high-frequency currents were widely introduced during and immediately after World War II but that little is now heard of new, large-scale technological improvements in machine building. He stated, "Our machine builders restrict themselves on the whole to employing already assimilated technological procedures, although new, progressive processes have been devised that permit a several-fold rise in labor productivity and the manufacture of more products in the same plant space."

The Russian premier told Soviet industrial leaders not to be so smug about their past achievements and to spend more time studying automation developments in other countries. He hit at petty jealousies among factories and scientific research institutes and called on them to work together more closely.

V. Trapeznikov, head of the USSR's Automation and Telemechanics Institute, said that machine builders are not meeting Russian industry's automation requirements either in quantity or variety. He noted that 30 different ministries and departments are en-



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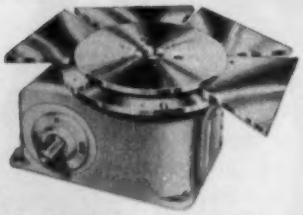

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There is a standard Intermittor for almost every application, offering a choice of stops, dial size, degree of movement; and a table for either extreme precision or high torque usage. Seldom do you have so much selection in a line of standard production machinery... with all of the benefits of standardization PLUS many of the advantages of custom designs! The Intermittor operates at speeds far greater than those possible with other types of index tables. The special acceleration characteristics of the FERGUSON ROLLER GEAR DRIVE insure smooth starting and stopping with little shock and vibration, at speeds up to 500 indexes per minute.

Save design time, simplify tooling, improve product quality and cut maintenance costs to rock bottom with the new Ferguson Intermittor... the "Packaged" precision index table for high speed production.

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gaged in automation work, each making small amounts of equipment suited to its own narrow needs and failing to co-operate among themselves.

While the USSR has shown only modest accomplishment in planning, development and introduction of advanced technological processes in industry, its potential should not be underestimated. This is especially true if Russia decides to bring into this field some of its best scientific and technical personnel who have in the past been assigned to military projects. Soviet successes in designing and building jet aircraft and in making atomic and hydrogen weapons are indicative of achievements resulting from high-priority "crash" programs that are provided with the best in personnel, equipment and materials. It is noteworthy that in an effort to bring more order and responsibility into the automation program, Premier Bulganin reorganized the USSR State Planning Committee (Gosplan). He ordered the creation of a State Committee on introduction of New Technology, "which will direct and coordinate the work of all ministries in this field."

Pravada Comments

The official Communist Party newspaper *Pravda* has described some of Russia's progress and failures in the automation field. It declared: "Only a few automatic machine tool lines were introduced at machine building plants during the period from 1936 to 1946, but now there are several dozen. Such labor-consuming parts as cylinder blocks, cylinder heads, automobile gear boxes, automobile wheels, springs, pistons, bearing rings, etc., are processed on these lines.

"Radiators, chains and other items are assembled by automatic methods. With an automatic factory for aluminum automobile pistons now in operation, similar shops are being set up to produce pistons rings and pins. Machine tool factories are completing work on automatic lines to produce plowshares and moldboards, bolts, nuts, ball and roller bearings, valves, tracks and other mass-produced parts.

"It must be admitted, however, that the designing, assembling, adjusting and, in particular, the full utilization of automatic lines sometimes requires several years. As a result, the lines sometimes lose their original importance and require changes if the machine in which the part is used has been modernized or its design altered.

"Only in exceptional cases should the lines be designed on the basis of entirely new machine tools developed for some complicated part. Also, to achieve maximum economic effect, it is advisable to give priority in automation to mass-produced parts for machines of more or less static design so that the expense of introducing automatic lines can be fully recovered."

Pravda also pointed out that some designers, in striving for maximum compactness of automatic lines, forget that it is necessary to ensure normal conditions for their servicing — with extensive down time resulting. "One scientific-research institute worked out an original design for an automatic line to produce rake teeth which permitted displacing of about 40 workers. However, the designers paid little attention to providing favorable working conditions for the electricians and machinists, thereby making repairs and adjustments on the equipment much more difficult. One could cite many such examples. Success in building automatic lines depends to a large degree on the quality of equipment design and manufacture. Unfortunately, this is not always taken into account.

"The Ordzhonikidze Machine Tool Factory, for example, made milling and boring machines for automatic lines producing piston pins and sent them to the Red Engine Factory at Novorossisk without testing them. After all the equipment was assembled, difficulties with these two types of machines delayed starting of the automatic lines for a long time.

"The Moscow Inner Grinding Machine Factory designed and produced for this same automatic line nine special centerless grinding machines weighing about 50 tons each, even though the grinding in this instance could have been accomplished by standard and

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At a leading automobile plant, Planet Corporation has designed and installed a 3,400 foot multi-story dragline. It moves auto bodies through a series of lacquer spray booths, and then through drying ovens to the trim line for trim, upholstering, and glass.

Before this installation, the floor grating in the spray booths had to be removed frequently for cleaning because of lacquer accumulation.

Now, the grids are self-cleaning. They move at a rate of a few inches per minute, passing through a series of cleaning tanks under the floor.

The Planet solution to this problem has resulted in a substantial savings in cost and time.

An automatic system of this kind is just one of many ways Planet engineers can help you solve your particular materials handling problem. Their experience and know-how is available, without obligation. Write today.

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sufficiently productive machines weighing six to eight tons."

Pravda said that even the largest specialized factories making complex precision products are careless in designing and manufacturing equipment for automatic lines. It suggested that factories ordering such equipment should in the future be given an important role in its design and production, "since the customer is, after all, the most interested party."

Measures Clearances Of Rotating Shafts

ORIGINALLY manufactured for the U. S. Navy the mutual inductance micrometer developed by Minnesota Electronic Corp. is now available to industry. This instrument, which has been tested by the National Bureau of Standards, measures the dynamic clearance of a rotating shaft, and thus indicates its eccentricities. The micrometer operates on a mutual inductance principle which permits detecting of shaft to bearing clearances by means of six Mumetal U-shaped probes. Three of these probes, or sensing heads, are mounted on each end of a shaft; preferably 90 degrees apart. Variations between these probes and the rotating shaft are compared with a precisely calibrated voltage reference level to indicate the reluctances in the air gap between the face of the probe and the rotating shaft. Clearance is read incrementally on a meter for each probe and converted to mils from a calibration chart. Having a measurement range up to a speed of 6,000 rpm, the mutual inductance micrometer gives highly satisfactory performance for turbines, marine engines, and other land and shipboard installations.

PURCHASE of the Liston-Becker Instrument Co. by Beckman Instruments, Inc., has been announced. Liston-Becker is a manufacturer of infrared gas analyzers used in chemical and medical research and industrial process control.

"Acquisition of Liston-Becker is another significant forward step in the planned expansion of Beckman Instruments into new fields of instrumentation and automation," said **Dr. Arnold O. Beckman**, president of the corporation. "New instruments are constantly being developed in our own research laboratories," Dr. Beckman said, "but it is also our policy to acquire instruments of outstanding merit developed by others when such instruments will enable us to provide more complete instrumentation service to our customers."

NEW machine element recently developed in Germany is now being manufactured and marketed in the United States by the U.S. Automatic Corp. The Gripspring offers a completely new approach to the problem of fastening hubs onto a shaft without the use of splines or keyways. The Gripspring also provides an assembly which has all the advantages of a shrink fit without any of its disadvantages. No clearances are present in this type of assembly. The new device is wedged between hub and shaft under pressure made by hand tools. The outer ring expands and the inner ring contracts. The units transmit the maximum torque for a given shaft diameter because full strength of both hub and shaft is utilized. Among the advantages are: Elimination of stress concentrations and notch effects, easy to assemble and disassemble, eliminates costly machinery and hand-fitted assemblies, and hermetically seals hub to shaft.

Handbook Service

PREPARATION of handbooks describing the operation and maintenance of equipment in industrial plants is a new service offered by Kenneth A. Young Associates. The handbooks are prepared by engi-

ENGINEER, ENGINEERING PHYSICIST OR PHYSICIST FOR PERMANENT POSITION
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Near Portsmouth, Ohio, this plant is the newest addition to the AEC Gaseous Diffusion program for production of fissionable materials.

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neers who go into the customer's factory or other installation, and gather facts about the particular equipment from drawings and personnel on the job. Handbooks for new plants would be prepared in conjunction with architectural and engineering firms responsible for designing the installation. The systems are described and illustrated, operating instructions are presented and maintenance and trouble shooting data are included where applicable.

MEETINGS AND EVENTS

Nov. 13-18—

American Society of Mechanical Engineers. Diamond Jubilee Annual Meeting to be held Congress, Conrad Hilton and Sheraton-Blackstone Hotels, Chicago, Ill. Additional information may be obtained from T. A. Marshall Jr., 29 West 39th St., New York 18, N. Y.

Nov. 14-17—

Second International Automation Exposition. To be held Navy Pier, Chicago, Ill. Additional information may be obtained from exposition headquarters, 845 Ridge Ave., Pittsburgh 12, Pa.

Nov. 14-18—

American Society of Mechanical Engineers. Exposition of power and mechanical engineering in conjunction with 75th anniversary meeting. To be held Chicago Coliseum, Chicago. Additional information may be obtained from International Exposition Co., 480 Lexington Ave., New York 17, N. Y.

Nov. 28-Dec. 1—

Air Conditioning & Refrigeration Institute. Ninth Air Conditioning & Refrigeration exposition to be held concurrently with national conventions of five interested societies and associations including the American Society of Refrigerating Engineers. Show to be held in Auditorium, Atlantic City, N. J. Additional information may be obtained from Institute headquarters, 1346 Connecticut Ave., N.W., Washington, D. C.

Dec. 5-7—

University of Wisconsin. Engi-

Why let the 4th DIMENSION limit your machine tool output?

A trip to the washroom or tool crib, a halt for feed finger repair, a spinning empty chuck—these interruptions to the steady flow of production can never be made up . . . for TIME, the 4th Dimension, waits for neither man nor machine.

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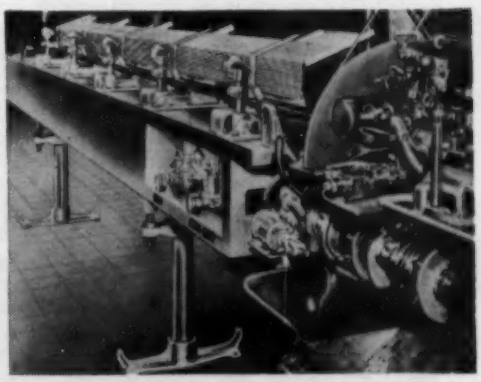
Lipe A.M.L. Bar Feed Eliminates Time Losses, Increases Output 30% or More

The Lipe Automatic Magazine-Loading Bar Feed is an air-operated attachment which holds an 8-hour supply of bar, rod or tubing and feeds it continuously to any machine equipped with a fixed stop. There are no feed fingers to break down—nothing to scratch or mar polished stock. It will feed any length in one feed-out, thereby cutting cycle time. Remnants are ejected automatically. Idle operation ("cutting air") is eliminated.



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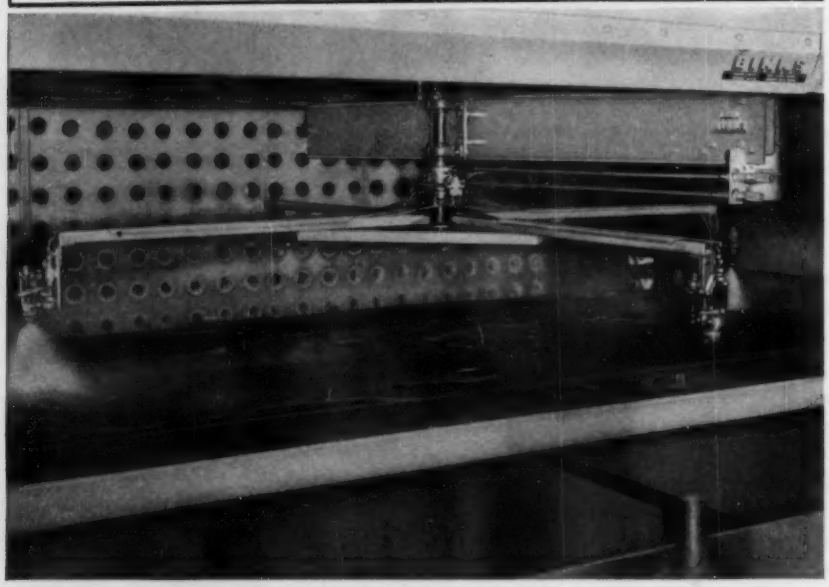
NEW USES for automatic spraying equipment



450 hides per hour coated by Binks Rotary Spray Machine

Large leather hides are being sprayed automatically with a coloring and preservative emulsion at the rate of 450 an hour at Gutmann & Company, one of the country's largest tanneries, located in Chicago. The emulsion is applied uniformly by four automatic spray guns on a Binks Rotary Spray Machine.

Aside from the capacity to apply coatings on hides at extremely high speeds, the Binks Rotary Spray Machine has many other money-saving applications and advantages:

Uniform high quality of finishes because spray guns and nozzles give dependable service...hour after hour...without fatigue.

Less waste of materials... guns operate only when over the product...are adjustable for products of various widths.

Variable speed control permits synchronization of the rotating arms and the conveyor to provide required coverage. On some flat products conveyor speeds of 100 feet per minute are maintained without sacrificing quality of finish.

Less maintenance and wear because of fewer moving parts which travel at slower speeds.

The Rotary Spray Machine is only one of the several automatic finishing machines made by Binks. Round and many-sided products can be finished at high speeds on a Binks Automatic Spindle Machine. For parts suspended from overhead conveyors, a Binks Vertical Reciprocating Machine is ideal. Almost any mass-produced product can be finished automatically with great savings in time and labor.

FOR ENGINEERING HELP—A Binks engineer will analyze your operation and make specific recommendations on ways to speed up your production or to obtain better finishes. No obligation. Just write direct to the address below.

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neering Institute on industrial plant maintenance. To be held University of Wisconsin, Madison, Wis. Additional information may be obtained from University Extension Div., University of Wisconsin, Madison 6, Wis.

Dec. 5-9—

Twenty - fifth Exposition of Chemical Industries. To be held Commercial Museum and Convention Hall, Philadelphia. Additional information may be obtained from International Exposition Co., 480 Lexington Ave., New York 17, N. Y.

Dec. 10-16—

International Atomic Exposition. To be held Public Auditorium, Cleveland, Ohio. Additional information may be obtained from International Atomic Exposition, 931 Book Bldg., Detroit 26, Mich.

Dec. 12-16—

Engineers Joint Council. Coordinating activities of 29 business and technical societies in co-sponsoring of Nuclear Engineering and Science Congress. To be held Public Auditorium, Cleveland, Ohio. Additional information may be obtained from Engineers Joint Council, 29 West 39th St., New York 18, N. Y.

Jan. 23-26—

Plant Maintenance and Engineering Show. Exposition and conference to be held Convention Hall, Philadelphia, Pa. Additional information may be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

AUTOMATION

"You see automation at work all through the plant."

DETROIT DATELINE

By FLOYD G. LAWRENCE Detroit Editor

NEW LOOK IN AUTOMATION

TRANSFER MACHINES have often been dubbed "the cornerstone of Detroit automation." The transfer bar has shuttled its way into the history of automated production and still plays a basic horn in the automation orchestra. But the architects of Detroit automation know that it takes more than cornerstones to build a durable structure. Machining requirements of any given part join forces with considerations of quantities required and dictate the production process sequence.

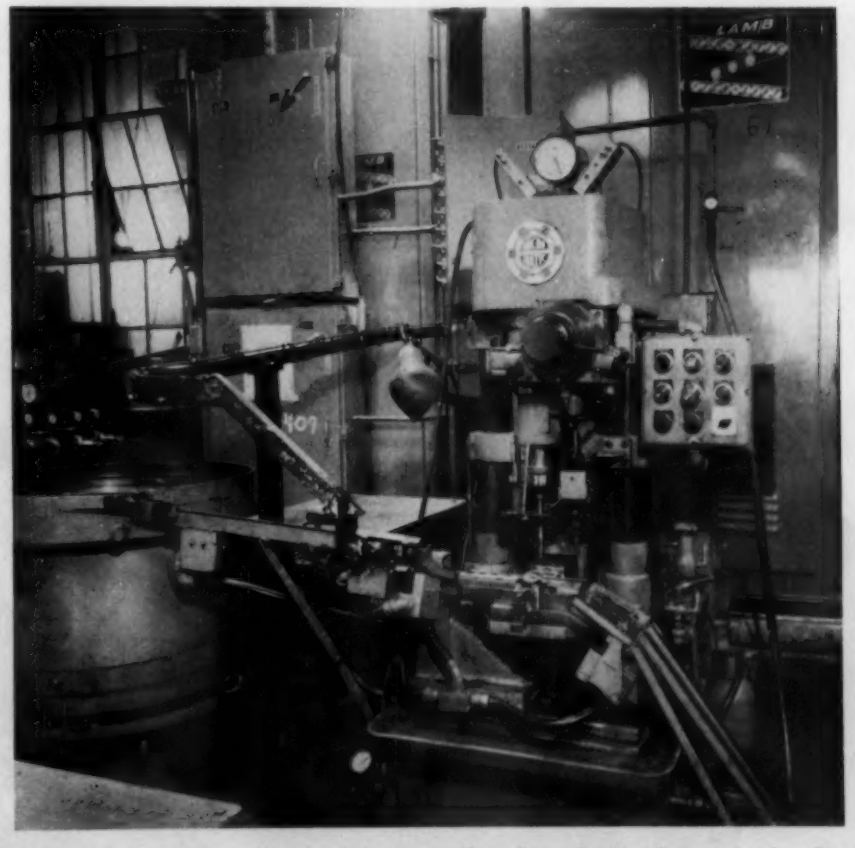
Whether the machining operations are performed at various stations of a transfer machine or on standard machine tools equipped with automatic feeding, cycling, and gaging devices and linked with parts handling equipment is the $64,000.00 question for the master mechanic.

Chrysler's vice president, Robert T. Keller states, "The initial trend in automation was toward larger and larger and more and more complex pieces of machinery. This soon reached a point of diminishing returns. Not only did the machines become so clumsy and inflexible that they rapidly reached obsolescence, but maintenance problems often made the huge machines almost worthless. If one small part failed to function, the entire operation went down. Sometimes an entire plant would have to be closed down because of the failure of one complex, vital machine. The latest trend is toward what we at Chrysler call 'integrated automation.'

"We want small, fast, more simply constructed units that can be tied together by mechanical production aids into flexible automation units. These units do not look as ingenious as the large complex machines, but they are more spectacular in their production records. Our new Plymouth engine plant, the most modern and most highly automated plant of its kind in the world, was designed, built, and equipped in accordance with this thinking."

A look at Buick's new line for machining Dynaflow pinion gears shows this trend in action. Here Heald borematics, Fellows gear shapers, National Broach, Michigan Tool, and Fellows gear shavers, work with Micromatic hones and Gardner and Sheffield grinders in a plant layout arrangement that looks like Detroit in the pre-automation days.

Although scanning the plan might remind you of yesteryear, the close-ups show each machine is rigged in modern attire. This style includes a complete array of what the automakers are calling "mechanical production aids." Lamb Stor-matic and Hitch-lift, Feedall and Syntron feeders, Interlakes Engineering Roto-lift, and



Micromatic honing machine is fed parts either from the Lamb unit in the distribution system or from the reserve supply in the Syntron feeder. This arrangement compensates for unbalance of machining cycles

MISSILE SYSTEMS

Research and Development

Broad interests and exceptional abilities are required of scientists participating in the technology of guided missiles. Physicists and engineers at Lockheed Missile Systems Division are pursuing advanced work in virtually every scientific field.

▪ ▪ ▪

Below: Missile Systems scientists and engineers discuss future scientific exploration on an advanced systems concept with Vice President and General Manager Elwood R. Quesada. From left to right: Dr. Eric Durand, nuclear physicist, systems research laboratory; Ralph H. Miner (standing), staff division engineer; Dr. Montgomery H. Johnson, director, nuclear research laboratory; Elwood R. Quesada; Dr. Louis N. Ridenour (standing), director, program development; Willis M. Hawkins (standing), chief engineer; Dr. Joseph V. Charyk (standing), director, physics and chemistry research laboratory; Dr. Ernst H. Krause, director, research laboratories.

▪ ▪ ▪

Scientific advances are creating new areas of interest for those capable of significant contribution to the technology of guided missiles.

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EXHIBITION

Boston, Mass., Nov. 7-9

The technology of guided missiles is literally a new domain. No field of science today offers greater scope for creative achievement.

Physicists and engineers with special abilities applicable to this field will be interested in new developments at Lockheed Missile Systems Division.

P. E. Alpine and senior members of the technical staff will be available for consultation at the convention hotel, HAncock 6-2044

Lockheed

MISSILE SYSTEMS DIVISION

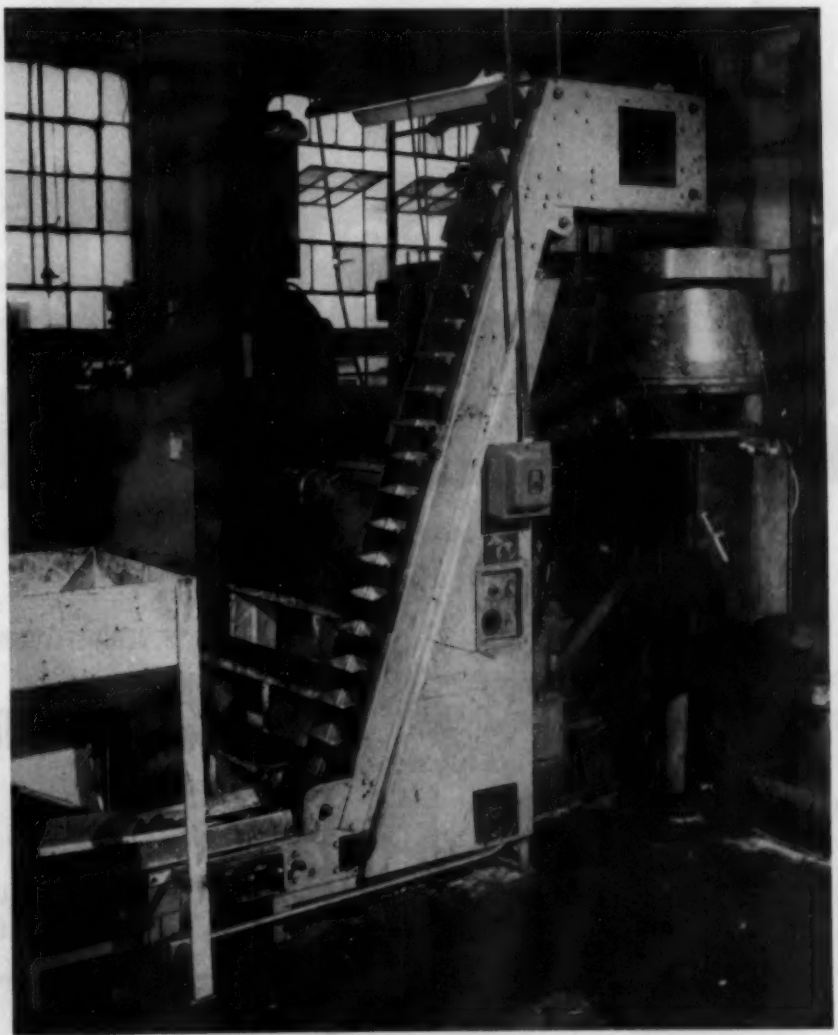
Sheffield Lectrolair units tend to such details as dispatching and distributing the parts to the machines, orienting and feeding parts to the tooling that automatically loads the equipment, and the gaging of each machine's output to feed back correction signals that keep the machine settings on tolerance.

Any production dispatcher who ran his young legs as a stock chaser in the old type of production department will tell you of the headaches involved in keeping each machine supplied with parts on which to work. He lived in constant fear of missed operations; lost parts; scrambled boxes of scrap, salvage and good parts; and of the wrath of the old man when he was caught with his tote pans cluttering up the aisles.

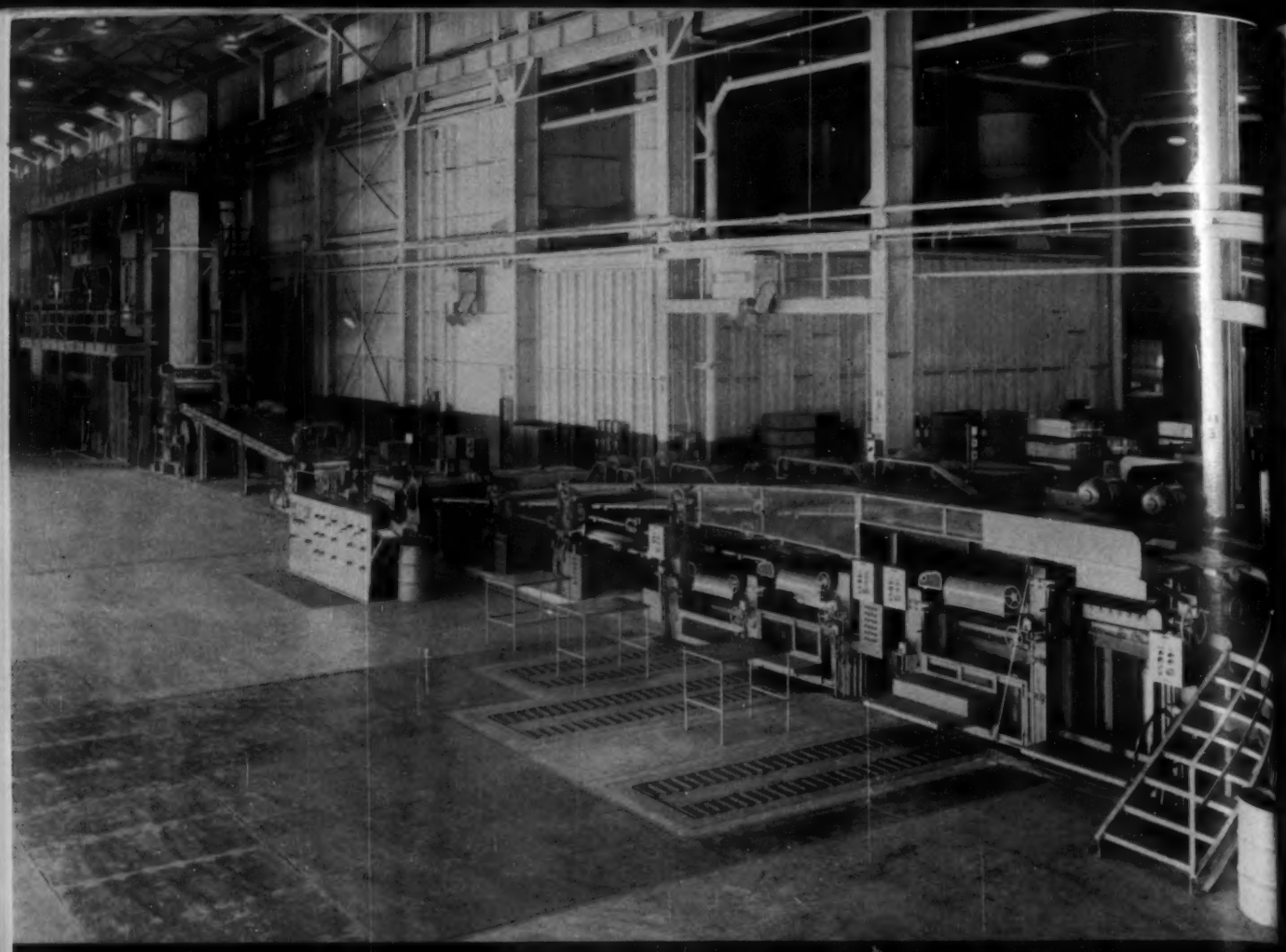
The solution of these problems by the automation engineer entails effective use of parts in process reservoirs, and ingenious distribution systems. As in the case of feeding 15 gear shapers which are all performing the same operation provisions must be made to: Supply each machine with its assigned portion of incoming parts, shut down any machine not performing at the acceptable quality level, by-pass those machines that are down, and continue to feed the remainder a proper dose.

The system must also provide parts to keep these machines going when the previous operation is shut down.

Certainly the basic units utilized in automated lines such as this have a flexibility that will enable them to be adapted to meeting production deadlines for years to come.



Interlakes Engineering's Roto-lift feeds vibratory hopper that supplies the chamfer grinder in Buick's Dynaflow pinion gear line



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GOOD EQUIPMENT BRINGS DOWN PRODUCTION COSTS

A Little Tailoring

In the manufacture of hardware and mechanical products, few things have so profound an effect on production costs as do the general design characteristics. Even seemingly minor configurations of component parts can add or subtract significant costs.

Study of products for automatic manufacture can reveal important factors that create costly production difficulties or impede proper automation. While it is possible to design equipment to produce a particular product automatically, the maximum cost advantage lies in the direction of tailoring the product specifically for automatic processes. Once the desired level of output is determined, the processes most suitable for production can be selected and the product tailored accordingly.

Some of the specifics for such product tailoring are developed in the lead article in this issue. Basic rules for study can help in general product evaluation and guide new design planning. The actual cases of such engineering on record reveal the unusual possibilities, and the savings speak for themselves.

To many the idea is radical—tailoring the product to the process—but the results can be amazing. These "tremendous trifles" of product design hold the secret to economical and practical automatic production.

EDITOR

AUTOMATION

DESIGN FOR AUTOMATION

Numerous factors can create the need and desirability for automatic operations. Significantly, the most important reasons outside of merely increased output are decreased waste and improved quality. In the fields of hardware, mechanical goods and other products, the impressive cost savings possible through automation can be most effectively obtained by careful assessment of certain fundamentals—product and process design and the automatic system. This article evaluates these basic factors and presents some general rules for consideration

By ROGER W. BOLZ
Editor

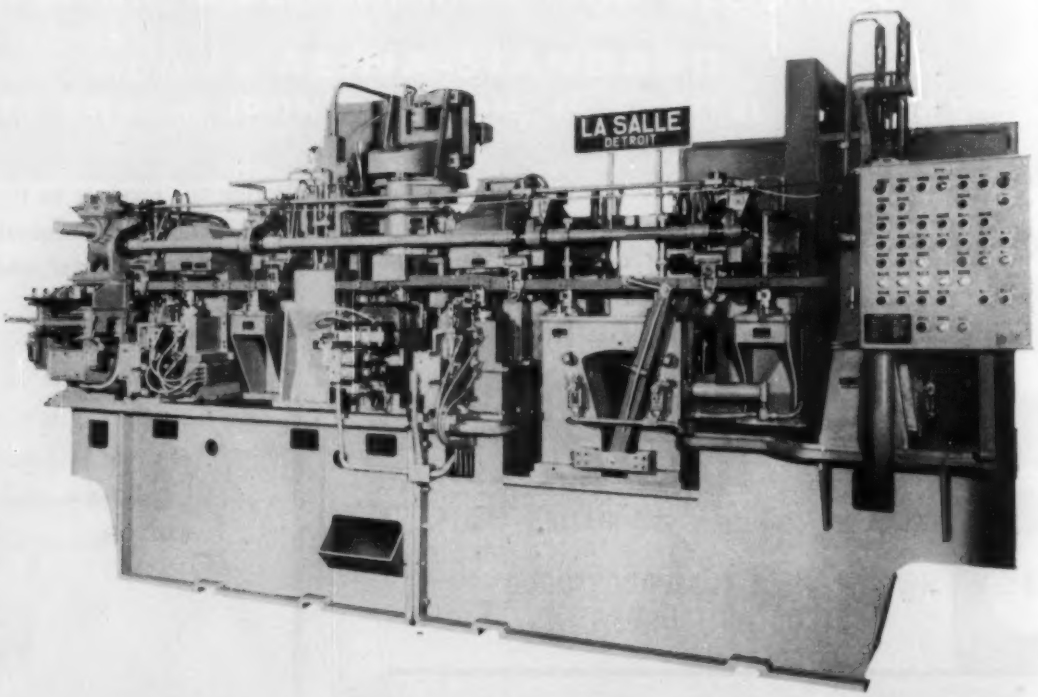


Fig. 1—One of two machines built by LaSalle Tool Inc. for fully automated piston manufacture. Pistons are firmly held by nylon fingers through 26 production steps. Pistons are produced at a rate of 400 per hour, checked and balanced to an accuracy of plus or minus one gram. Adjustments permit handling different sized pistons

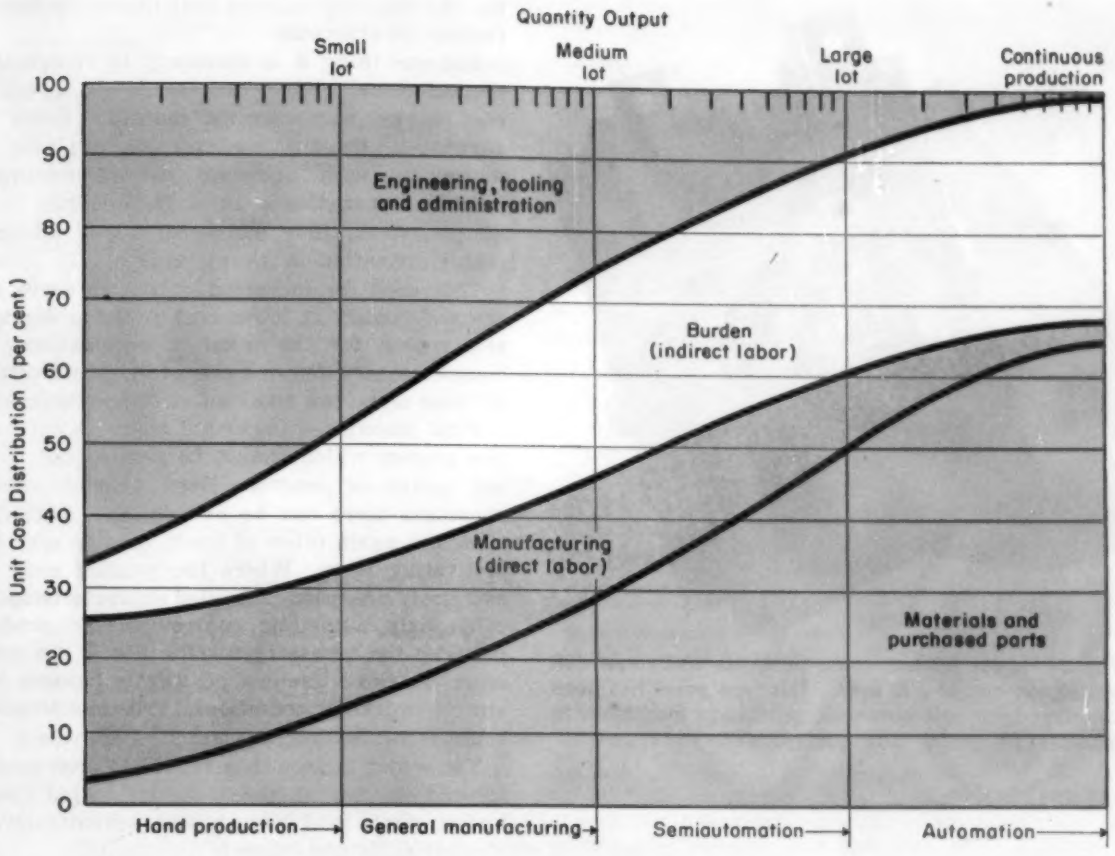


Fig. 2—Unit cost distribution factors charted in relation to production output to show the changing emphasis as production moves into the area of automation

I CAN SEE EASILY how their industry can use automation, and it's good, but our industry is different!

So the comment goes, but is your industry different? Careful check will reveal a startling similarity in basic industrial problems. As with mathematics, once the problem is reduced to real known values, it will usually succumb to effective solution by basic established engineering procedures. And like mathematics, automation is not peculiar to any one industry. It is a fundamental engineering technique and offers equally outstanding results regardless of the industry or area of application. Almost any manufacturing, processing or service industry can use automation in some degree profitably. This article, relating mainly to hardware and mechanical products, will examine the possibilities and present some basic considerations for effective automation.

What Is Automation?

Today's accepted interpretation of automation is "continuous automatic processing". And by processing is meant or implied all industrial processes or services including the closely related area of data processing, especially as it ties in with industrial or commercial enterprise. It is a method of manufacturing, processing or performing services, based on the idea of continuous or programmed operation rather than the more common separate or single-stage methods of operation. The method encompasses both fully continuous operations as well as automatic step or batch type operations, *Fig.* 1. Which type is most suitable depends upon the product and the process characteristics and other conditions of processing necessary.

Operational Study

What is the fandamental approach to automation in manufacturing? Can a basic study reveal significant factors for practical guidance? The answer of course is yes.

While at this stage of evolution no concise engineering approach to industrial or commercial automation is practical, it is possible to present a general study for evaluation. Once the problem is reduced to finite proportions, work can be channeled into those areas which promise the most effective solution. What is being sought is adapt-

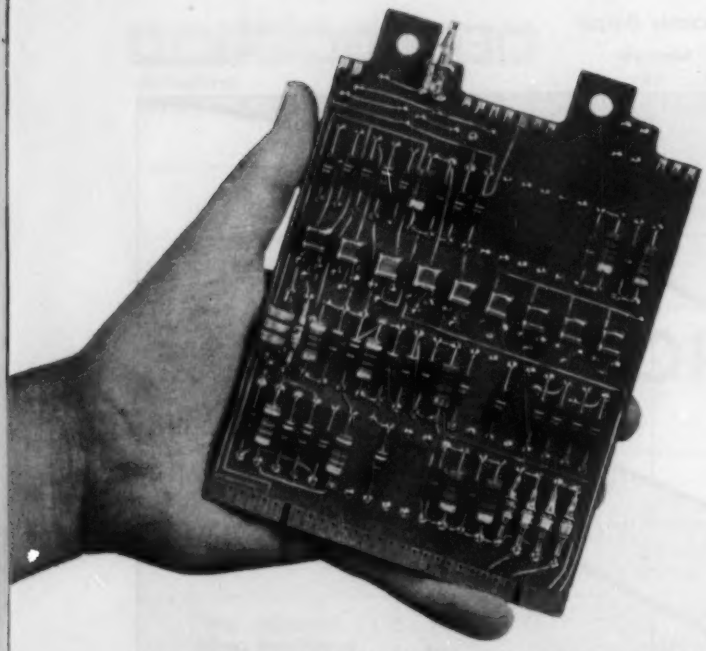


Fig. 3—Plug-in printed wiring panel for IBM's new 608 calculator, one of 700 used. This type panel has been developed for fast automatic production techniques to increase uniformity and quality

ability of the product to permit integration of specific processing steps into an economical continuous system.

It is fundamental to understand the primary reasons which can create the need to automate regardless of the scale of operations or their general character. To assume or conclude that elimination of labor or reduction of the usual labor force is the main objective is erroneous. True, cases are on record revealing this as the primary purpose, but the majority indicate that the really important factors are otherwise.

For one thing it is necessary to recognize that decreased unit labor cost or lower direct labor cost in no way directly indicates fewer plant personnel. On the contrary, in applying automation to meet increased market requirements industrial statistics show a gradual rise in overall personnel. How increased output affects unit cost distribution is shown in *Fig.* 2.

This need for increased output to serve an increased market at lower cost is but a single general reason for the trend to automation. Other complementary reasons are present and often one of these alone can make automation a necessity.

First among the important spurs to automate is the process which cannot be carried out by manual means or control. Here without automatic operation there can be no process. Linked with this, and again often of itself, quality may be the motivating force. Where the product must be of extremely uniform, controlled characteristics, most often only automatic control and/or production provides the necessary results, *Fig.* 3. In addition must be those factors of safety hazards, undesirable working conditions, and monotonous or brute labor, no longer attractive anywhere.

The major factors then reduce to increased quality and uniformity, speed, safety, output (reduced losses, waste and scrap) and job attractiveness (higher skills and wages).

TWO MAIN PHASES: In evaluating automation possibilities for any particular manufacturing process, there are two main phases which should be seriously studied. These are as follows:

1. Product and Process.
2. Automatic System.

These are listed in order of their importance and only in those few cases where an absolutely fixed product or process is concerned does Item 1 lose

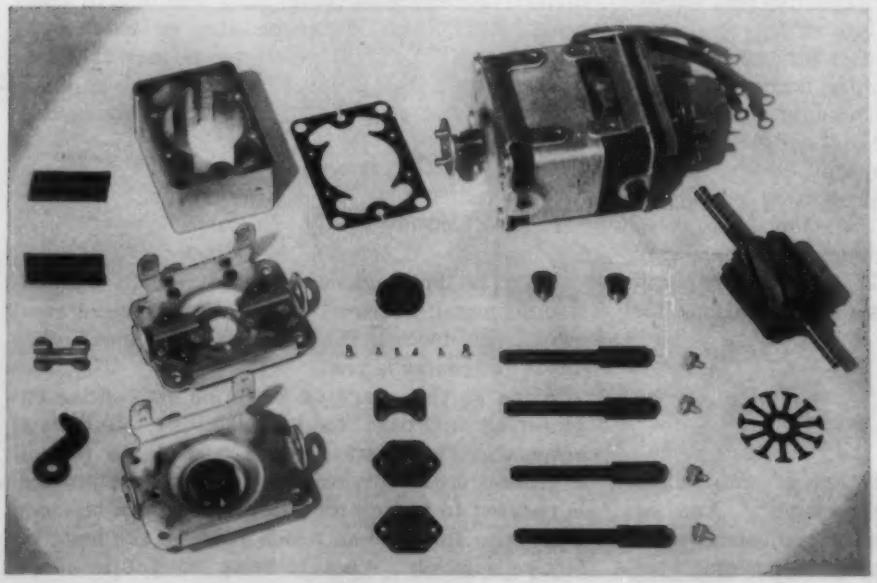
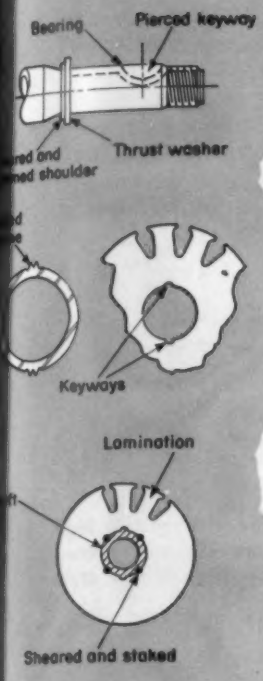


Fig. 4 — Friden Calculating Machine Co. office machine motor redesigned for lowest cost production almost entirely from stampings. With a minimum number of parts, simplified components and standardized end plates this open design eliminated need for a cooling fan



SEQUENCE OF OPERATIONS

Solid Shaft	Hollow Shaft
Operation No.	Operation No.
1. Turn all diameters and cut off (an automatic screw machine)	1. Roll tube from hot rolled strip stock, weld, and cut to length
	2. Nose ends of tube
2. Centerless grind OD of shaft, rough, and finish	3. Centerless grind OD of tubes, rough, and finish
	4. Wash tube and coat with trisodium phosphate
	5. Extrude drive end of shaft, shear thrust shoulder, and extrude extreme end for later thread rolling. Press with indexing dial
	6. Machine drive end of shaft on special machine
	7. Extrude commutator end of shaft, and shear oil slinger on second press
	8. Machine commutator end of shaft
6. Mill keyway	9. Pierce keyway with press
4. Wash	10. Wash
5. Centerless grind both bearing diameters of shaft	11. Centerless grind both bearing diameters of shaft
7. Roll threads with thread roller	12. Roll threads with thread roller
3. Knurl OD of shaft	13. Roll splines on OD with special machine
8. Inspect	14. Inspect
9. Ready to have laminations assembled	15. Ready to have laminations assembled

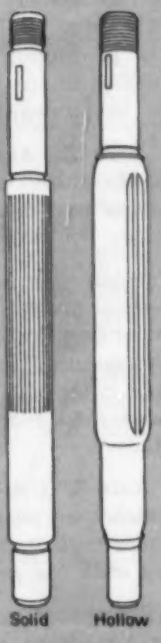


Fig. 5—Change of this automobile generator shaft from conventional solid steel to hollow welded steel tubing by Delco-Remy Div. produced substantial material savings. The production sequence was made automatic including transfer from operation to operation. Even though additional operations are required, high-speed processes ideally suited to continuous output actually created savings greater than expected. Use of unique pierced keyway rather than a milled keyseat created an effective retainer for the key and decreased production cost

its significance. However, because of their tremendous influence on the cost suitability of the automatic system, the product and process considerations should never be overlooked.

▶ Product and Process

Significantly important are the product and processing steps in automation operations. Ingenious developments in both these areas have revealed the effectiveness of good design. Thus, two main considerations must be brought into the picture for successful automation:

1. Design of Product.
2. Design for the Process.

Both are critical. Without the first consideration, the product design may necessitate processing steps which are actually useless, thereby rendering the system more expensive or possibly impractical. Without the second automation is often difficult or inadvisable.

It is no idle talk that, regardless of the principles developed, the skill exercised in creating products capable of inexpensive and easy manufacture often spells the difference between success and failure. Many otherwise excellent designs fail to succeed owing to manufacturing problems. With automation this factor can be greatly magnified in its overall importance. And, in many instances, the important adaptation leading to success may appear relatively of insignificant proportions.

DESIGN OF THE PRODUCT: The character of the product is always important. Few products exist that cannot be improved or simplifed. Manufactured products such as hardware and mechanical items are especially in this category. Final design should never be frozen until the production requirements have been evaluated.

In general a number of specific recommendations can be made. No one rule can be said to predominate; each case must be studied carefully for best ultimate results.

Rule 1. *Insure maximum simplicity in overall design. Develop product for utmost simplicity in physical and functional characteristics.*

Production problems and costs have a direct relation to complexity of design and any efforts ex-

pended in reducing a product to its "lowest common denominator" will result in real savings. This applies as well to individual items, components, and assemblies or subassemblies. Actually, simplicity is a great deal more difficult to achieve than not, but production costs bear a direct relation to complexity of the product and efforts to simplify will be well rewarded costwise, *Fig.* 4.

Rule 2. Analyze carefully all materials to be used. Select materials for suitability as well as lowest cost and availability. Seek economy of use.

Selection of materials to be used for any product can play a key role in attaining lowest costs. Special materials may create a production problem regarding availability. As production increases, the material form and use assume a commanding role in the unit product cost, *Fig.* 5. Overall possibilities to reduce material costs deserve careful study.

Rule 3. Use the widest possible tolerances and finishes on parts. Be sure that surface roughness and accuracies specified are reasonable and in keeping with the product and its functions.

Tolerances on surface finish and dimensions play an important part in the final achievement of practical production design. It is imperative that the principles of interchangeable manufacture be observed for successful low-cost mass production. All components of products should be surveyed carefully to assure not only successful processing but also rapid, easy assembly and maintenance.

Here, it is also important to keep in mind the influence of practical production design and that of standard available materials. Tolerances on dimension and finish characteristics with standard materials as well as that regularly produced with conventional production methods must be observed to attain suitablity and lowest costs.

Consideration should be given to the possibility of automatic inspection. Where processing requires in-process inspection it is often desirable to minimize the number of critical dimensions subject to close control during processing. Automatic inspection will aid immeasurably in eliminating production losses and rejects.

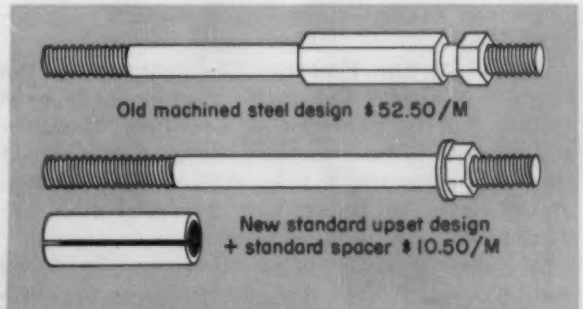


Fig. 6—Stud used by General Electric required production of 200,000 pieces per year. Automatic upset and roll threaded stud used with a standard roll-formed spacer in this instance offered worthwhile savings compared with conventional machined stud

Fig. 7—Warner Automotive Parts Div. changed to high speed stamping for producing this bracket and reduced cost 75 per cent compared with the original cast style

Rule 4. Standardize to the greatest extent possible. Use standard available parts and standardize basic parts for one product as well as across a maximum number of products.

Use of standard components in developing products needs no emphasis. Standard stock items cost less and require no development, *Fig.* 6. Also, in seeking best production design, standardization of components across product lines offers tremendous savings. In manufactured products this is a fertile field for attaining lowest costs and maximum output. Study of this phase has revealed some impressive opportunities and, in many cases, showed improved functional characteristics as a result of closely controlled automatic production made possible by increased volume.

DESIGN FOR THE PROCESS: It has been said that evolving the basic idea for a product constitutes about five per cent of the overall effort in bringing it onto the market; some 20 per cent of the effort goes toward general design of the product and about 50 per cent of the effort is necessary to bring about economic production of the product while the remainder goes toward removal of bugs from design and production, including servicing. The big job is in making the product economically—through design for automatic production, *Fig.* 7.

In a recent talk, William Newberg, president of Dodge Div., Chrysler Corp., brought out this important factor pointedly:

"While the importance of tool design to successful automation is well understood, the importance

of product design to good automation is not yet fully realized. The designers of parts must be thoroughly educated in the ways automation operates. The designer who is familiar with automation and who designs his product with automated production in mind can make the work of master mechanics easier and can save his company thousands and even millions of dollars. The simple precaution of designing a flange that turns out, instead of in, on an automobile body can make

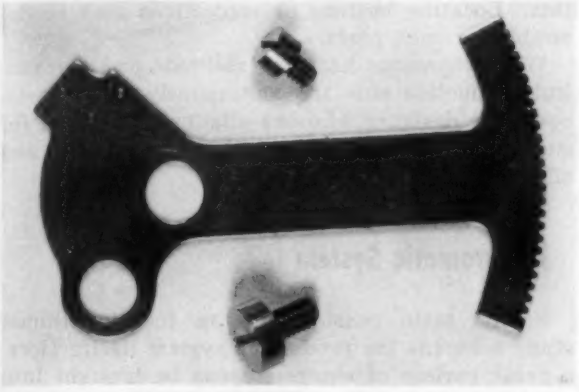


Fig. 8—Careful study of a product can reveal most suitable production methods. Fischer & Porter Co. revamped this sector gear to eliminate the two stop screws shown, both special. Process change to die cut the gear teeth instead of mill permitted eliminating the two end teeth so extra stops were not needed. Use of stamping and elimination of the screws reduced operations from 16 to 4, gave additional materials savings

the difference between a manual and an automated operation on the production line."

While it is possible to produce almost any product conceived, it does not follow that production costs will be reasonable or acceptable. Design should be planned whenever possible to suit basic operations available through the common manufacturing methods which can be tooled and adapted with minimum effort. Design that centers only around the product and its function generally creates the need for entirely special production facilities. Because such facilities may not always be justified economically, the practical aspects of design modified for available automatic production facilities are readily apparent.

Rule 5. *Determine the best production method or fabricating process. Tailor the product to specifically suit the production method or methods selected.*

It is distinctly possible to tailor the details of a product to assure economic production and it is possible to have a basically similar part which is excessively expensive to produce. Small but extremely important details can create this difference, *Fig.* 8.

Every component and subassembly of a product should be carefully studied to insure close observation of inherent limitations imposed by particular processing procedures. For instance, it is important to keep in mind that every production method has a well-established level of precision which can be maintained in continuous production without exceeding normal costs. Actually, no amount of inspection will improve this level. For practical reasons it must be observed.

The practice of specifying tolerances according to empirical rules should be abandoned. Practical design for automatic production demands careful observance of the "natural" tolerances available with specific processes, *Fig.* 9.

Again, the process or processes selected may be directly influenced by the anticipated or required quantity output. Many processes have quantity

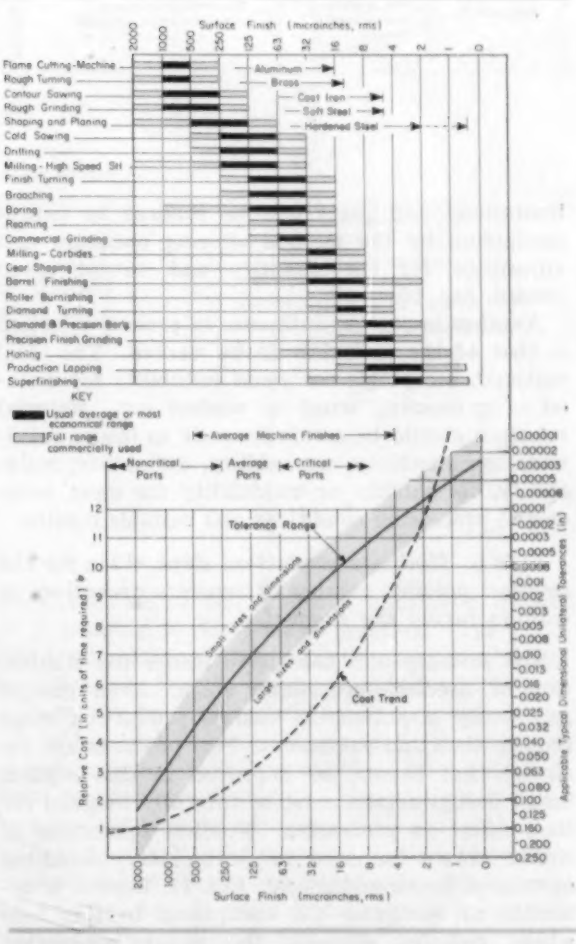


Fig. 9—Chart showing basic machining processes, their full and normal commercial ranges of surface finish, and their accompanying range of practical tolerances on dimension. Added refinements in terms of extra processing steps or time can vary these ranges somewhat. Use of automatic gaging can make minimum tolerances practical in production.

TABLE 1 — AUTOMATIC SYSTEMS

	Continuous Processing	Programmed or Step Processing
Product or Service Operation	Webs, fluids, chemicals, granular materials, ordnance	Mechanical products, electrical products, assembly operations, foods, metallurgical products, some chemicals
Character of Operation	Product subdivided at end of process	Product in discrete form during process
Basic Control	Continuous sensing	Triggered control
Type of Control Element	Instruments, servos computers	Tapes (magnetic, film, paper) Program timers (electrical, electronic) Limit controls (pneumatic, mechanical, electrical, hydraulic)
Handling	No separate handling in process	In-process handling mechanized
Adaptability	Fixed system with control adjustment	Fixed or flexible system with control adjustment
Production	High output	High or low
Feedback	Yes, wherever measurement is feasible	Yes, wherever necessary and measurement is feasible

limitations and parts can be tailored to permit production by the method offering optimum cost advantage for the quantity and output speed needed, *Fig.* 10.

Another important influence in process selection is that of the materials to be worked. The ideal material, acceptable costs and suitability for method of processing must be worked out. Material selection should be carefully made to insure maximum machinability, workability, castability, moldability, formability or weldability for most economical processing conditions and suitable results.

Rule 6. Minimize production steps. Plan for the smallest possible number of separate operations in manufacturing the product.

The primary aim here is to insure the elimination of needless processing steps. Even though processing is automatic, useless production steps require time and equipment. Few products are designed that cannot be improved in this regard. Small design details must be carefully weighed for their effect on processing. Needless operations of course create the need for unnecessary handling oprations, hence added cost, *Fig.* 11. Here it is desirable to recognize the exceptions to this rule where redesign changes the entire production sequence to attain other possible savings, *Fig.* 5.

Rule 7. Eliminate handling problems. Insure ease in locating, setting up, orienting, feeding, chuting, holding and transferring parts.

To simplify mechanized operation it is possible to tailor product design for most practical handling. It should be practical to transport parts, hopper feed, locate for assembly operations etc., without undue difficulty. The product should be rigid and compact where possible to withstand mechanical handling. Fragile projections should be eliminated.

It is desirable to design parts subject to hopper feeding so that tangling is avoided. Wherever possible, overall design should be developed to permit ready handling of the product in simplified steps by means of complete and independent subassemblies amenable to automatic assembly. Uniform symmetrical pieces may pose an orientation problem requiring specific means for sure-fire orientation. Locating buttons or projections may be desirable for such parts.

While ingenious handling methods and mechanical production aids are continuously being developed, the designer who can eliminate the need for such equipment simplifies production problems and effectively reduces overall costs.

▶ Automatic System

Second main consideration in the operational study concerns the production system itself. Here, a great variety of equipment can be brought into play for automation. Production equipment can range from a single multiple-stage setup to a complete production sequence. The line can be of simple open-lcop fixed control arrangement or include the higher level of in-process measurement and closed-loop feedback control. The product characteristics, processing requirements and practical considerations generally dictate the level of automation desirable. In the realm of equipment control, many new and potentially useful control methods are in development stages. The range of control is tremendous, hence, selection is the more difficult.

For practicability and economy, along with suitability, it is imperative that a minimum of control be employed for obvious reasons. Added complexity in no way enhances reliability and adds to the cost of production equipment. If the memory storage of simple electrical controls is adequate for a particular application, to contemplate use of a

PRODUCT AUTOMATION ANALYSIS

- Is customer acceptance high?
- Is basic design to be fairly constant for at least three years?
- Has design simplicity been maximized?
- Can models and components be combined or standardized?
- Is it adaptable for continuous processing?
- Can parts be mechanically handled without damage?
- Are tolerances production modified?
- Is automatic inspection practical?
- Can automatic assembly be used?

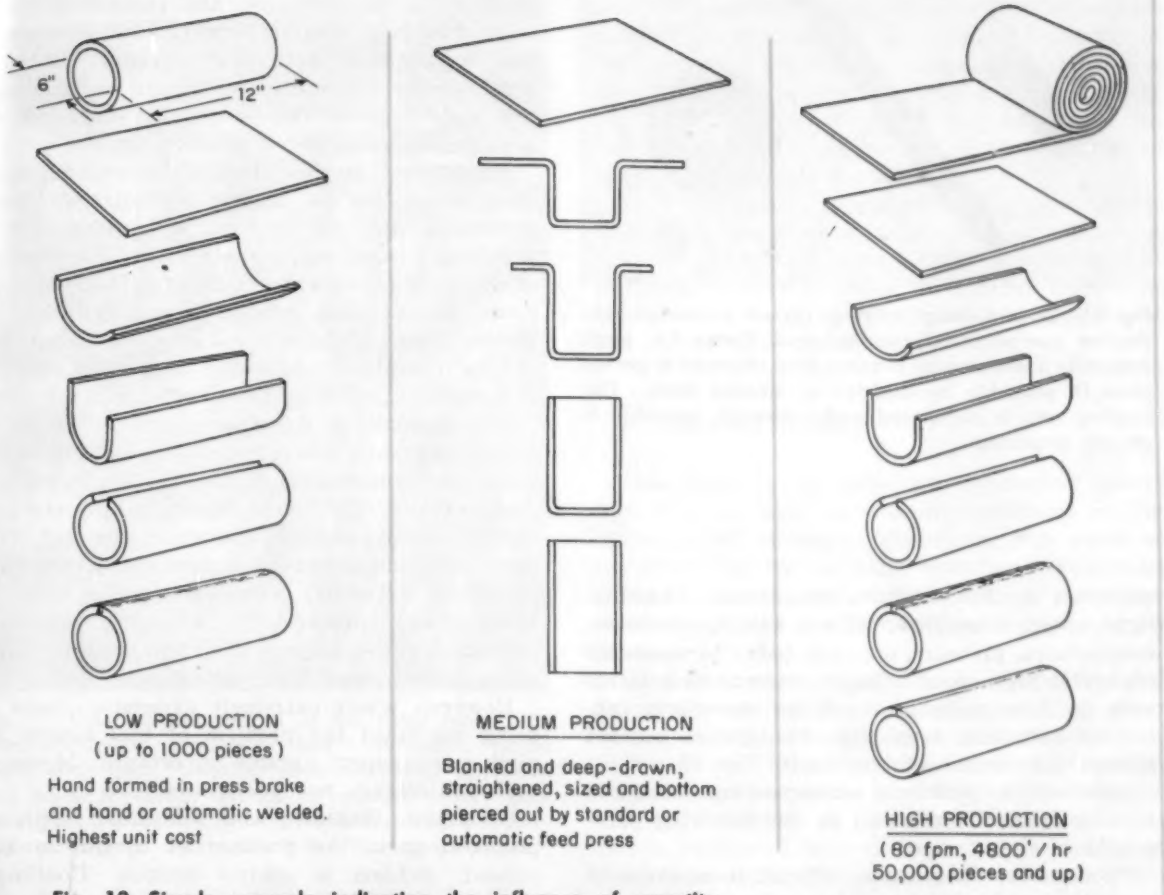

6"
12"
LOW PRODUCTION
(up to 1000 pieces)
Hand formed in press brake and hand or automatic welded. Highest unit cost
MEDIUM PRODUCTION
Blanked and deep-drawn, straightened, sized and bottom pierced out by standard or automatic feed press
HIGH PRODUCTION
(80 fpm, 4800'/hr 50,000 pieces and up)
Continuously roll formed to shape, resistance welded and automatically cut to length. Lowest unit cost

Fig. 10—Simple example indicating the influence of quantity on process selection for producing a tubular shape of large diameter and thin wall. Lowest unit cost is practical only where substantial quantities are required on each production run

more complex memory device not only opens wide the door to failure but is a sheer waste of equipment and cost. Again, to plan on use of tape controls for an operation where simple adjustable cam control will do the same job is just poor engineering.

As an example, to develop a tape controlled screw machine it would be necessary to be able to create a tape as economically as the present cams or adjustments used to produce a part and in addition perhaps offer the possibility of simple size adjustment or control. On low-quantity job shop production it would be necessary to "tape" a part for less than present "hand setup and run" operations, *Fig.* 12.

As a general rule it can be said that the type of product or the basic process employed will largely determine the basic type of automatic system used. The elements outlined in TABLE 1 will serve as a rough guide for general purposes.

While a high level of automatic control is possible, the use of full feedback automatic control of processing is not always practical. The problem is one of being able to set up exact measurable specifications for the product against which comparison can be continuously made to maintain the product output in close agreement. Here is where a real problem exists—measurable exact specifications are not always possible. Means in many cases have not yet been found.

The important point, however, is that very often no feedback in the process is necessary for successful results. And in certain instances it is actually impractical as well as not needed.

MEASUREMENT: In seeking successful automation, regardless of the type of operation, good accurate means for measurement may be needed for control. To exercise control it is usually necessary to measure the results of the operation being performed.

Certain types of measuring and sensing devices are readily available. Such straightforward meas-

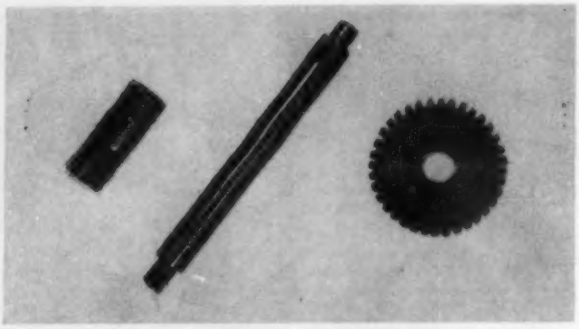


Fig. 11—Careful design analysis reveals unneeded production operations. These Fischer & Porter Co. parts originally assembled by brazing were changed to permit press fit assembly by addition of knurled ends. The brazing step is eliminated and automatic assembly is greatly simplified

urements as temperature, dimensions, humidity, light, speed, color, flow, volume, weight, resistance, conductance, pressure, etc., can today be measured closely at high speed. Simple direct measurements such as these make practical the closed-loop control of individual segments of a system but not always the overall system itself, *Fig.* 13.

Some of the problems accompanying control in specific areas are outlined in the following paragraphs.

PROCESSING: It is often difficult to measure or qualify certain processing stages for products produced. Besides having no method for measuring the characteristics of the end product, it is often difficult to control the quality and uniformity of the input or raw ingredients. Hence, accurate control becomes extremely complex. However if qualities to be measured and controlled can be kept relatively straightforward, suitable control can be obtained. Such characteristics as can be arranged for fast measurement can be included in the basic system. Others require inspection following completion of the product.

MACHINING: To date, the only machining operations which can be accurately controlled *during* processing are the finishing operations such as grinding, honing, lapping, etc. Here the character of the work permits use of direct measuring equipment. Nevertheless, control is still difficult. For instance, lack of full control over preliminary machining operations can cause high rates of reject in automatic grinding due to off-size blank pieces.

With machining operations, lack of means for detecting exactly where the tool is cutting or precisely the dimensions of the surface being produced creates a problem. Presently only end-point control appears feasible and where the cost of the part being machined is modest, such control is providing extremely effective results, *Fig.* 13. Measurement immediately following machining permits feedback control of tool position to correct minor trends away from desired size.

However, where extremely expensive pieces are being machined the problem of tool control and work measurement assume importance. Means for such control are not yet available.

STAMPING, WORKING AND FORMING: With die-produced parts the problem of control is miniminzed. Seldom is control serious. Continuous check on critical dimensions can be made by conventional means or by part counters set to coincide with rate of die wear.

ASSEMBLY: Extremely precise mechanical products to date appear to present the greatest chal-

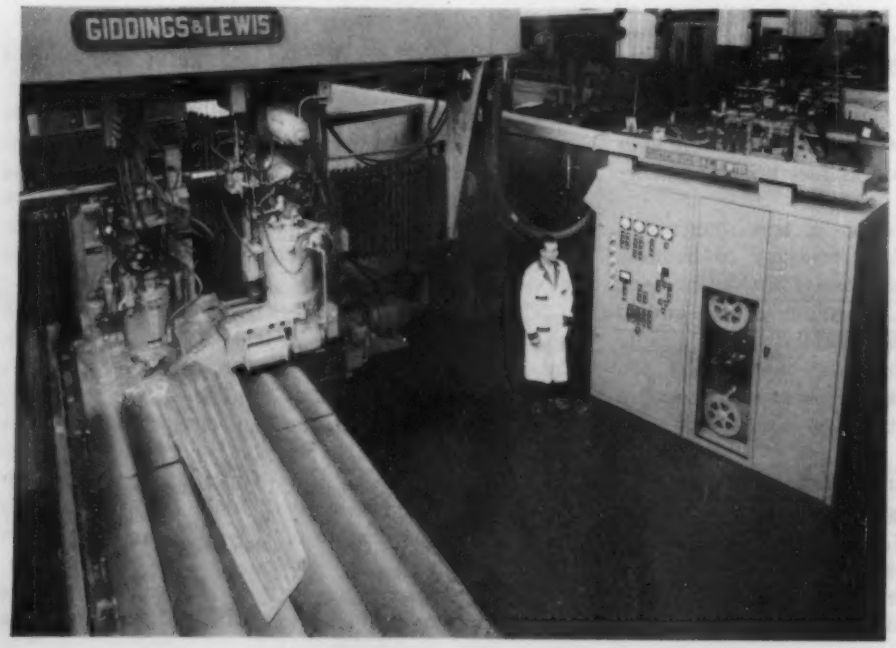


Fig. 12—Difficult "hand setup and run" operations on intricate contoured wing panels are eliminated with this new Giddings & Lewis tape controlled spar and skin miller. Control by magnetic tape is expected to achieve savings in milling time of up to 50 per cent compared with present hand control methods. Time and material losses as well as tool setting, template changing and gaging operations are eliminated. Once taped, any number of identical parts can be automatically produced

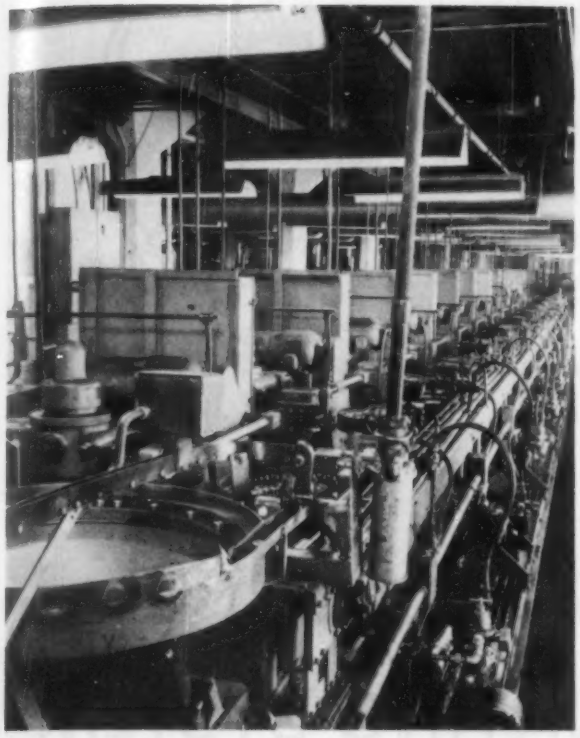


Fig. 13—Gear shaper section of the Buick Motor Div. automatic gear production line. Automatic gages check each gear following each machining operation and adjust the cutter settings as needed. Every gear undergoes fourteen machining inspections and one final test and gaging. Production is 3 million gears annually

lenge to automatic assembly. This is especially true with selective-fit assemblies. Far from precise means for machine control as well as measurement impose difficulties. Imperfect processes and common temperature effects introduce problems difficult to solve. Here, since really precise measurement and production may not be practical, selective hand fitting is necessary.

Mechanized assembly, however, is ideal for noncritical or specially designed units and components suitable for free random assembly. All manner of hardware and other units designed especially for random fit can be automatically assembled. Only size has been limited to date but automated assembly of automotive engines is now considered feasible and being developed.

With automatic assembly it is highly desirable that continuous automatic inspection of component characteristics be made. With high output of products, quality changes or control failure at any point in the system can result in high losses and exceedingly expensive rework.

▶ Improved Quality

This leads to an important concluding point: that of better and more closely controlled quality by means of automatic operations. Few areas so important receive so little attention. Automatic control of quality invariably results in more economical production. Tremendous savings can be made.

While better quality is desirable and offers real advantage in customer satisfaction, its other values can also be significant. Direct savings in materials can be made. Close control of quality substitutes elimination of defective products for the mere sorting of good and bad products to create additional savings in materials and labor. Better products can create ever wider markets and as a primary responsibility of management this increasingly important phase demands continuing and careful assessment. In tomorrow's market it will hold a prominent place.

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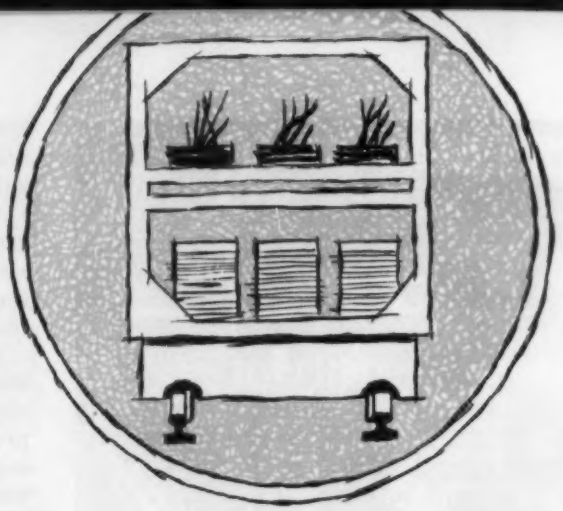
GAGING BY EMITTED RADIATION

X-RAY gages designed and developed by Jones & Laughlin Steel Corp. measure the amount of tin being applied to steel sheet in plating operations on three of their electrolytic tinning lines. The gages provide a continuous operating check that is precise, rapid and noninjurious to the product. They can measure tin coating thickness to within 0.0000006 of an inch. Each gaging installation includes an instrument for recording permanently the amount of tin applied to steel coil.

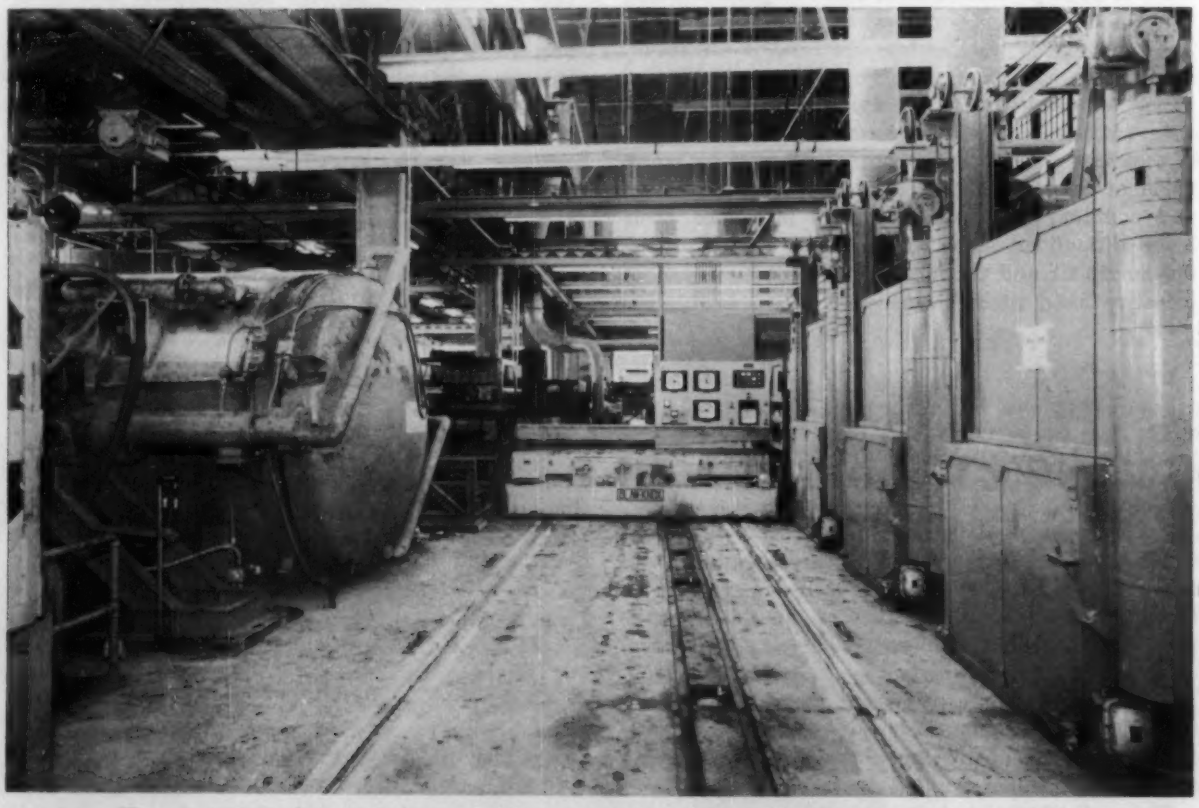
The method of measuring tin thickness makes use of the phenomenon of X-ray fluorescence. X-rays are beamed at a sheet of tin plate as it leaves the line at speeds of 700 to 2000 feet per minute. The beam causes the steel underneath the tin coating to fluoresce, giving off X-ray radiation which is partially absorbed in the tin coating. The amount of radiation received by a detector will decrease as the tin thickness increases, hence the output of the detector can be used to determine the thickness of the tin coating.

Equipment making up the gage includes an X-ray power supply and tube, a radiation detector, and necessary amplifying, indicating and recording mechanisms. Incorporated in the design of the gage are features that overcome mill problems of wide temperature fluctuation, humid air, and vibration. The X-ray gages replaced a slow, tedious, 60-year old chemical process of determining thickness of tin plate applied to steel.

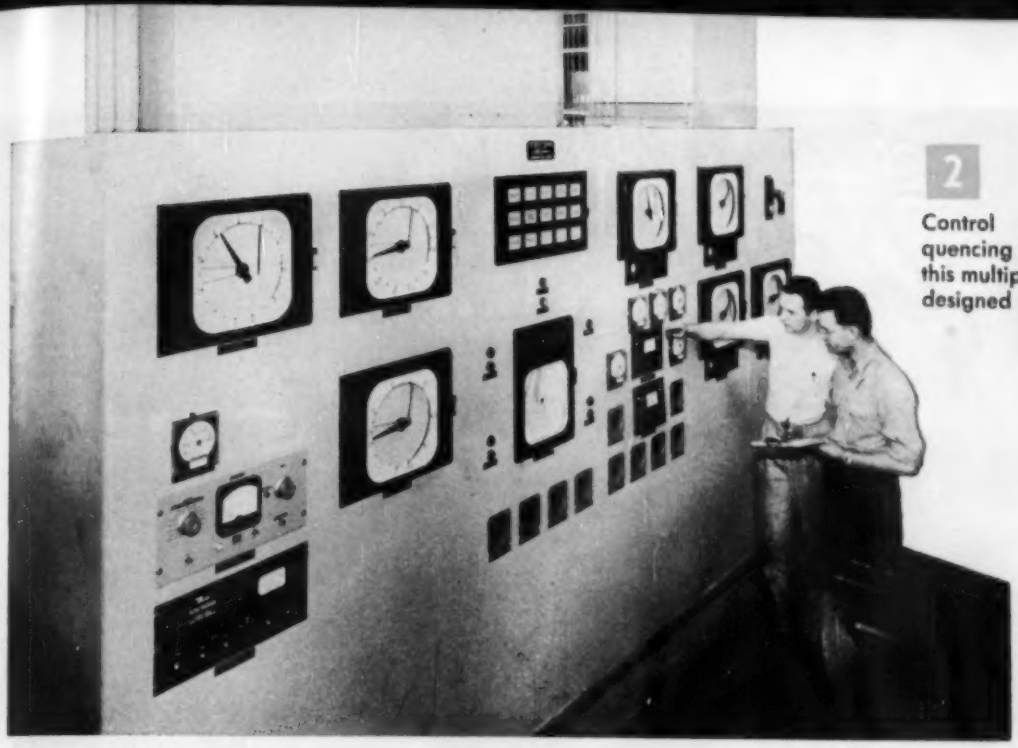


AUTOMATION TODAY

PALLET CARRIER SEQUENCES IMPREGNATING SYSTEM



1 Automatic impregnating system viewed from the discharge end, showing three ovens on the right, the car and carriage in the background, and impregnator on the left. Also seen in the background is a portion of the control panel. The car moves forward on the tracks shown in the center of picture, transferring loaded pallets to and from racks, ovens, and the impregnator



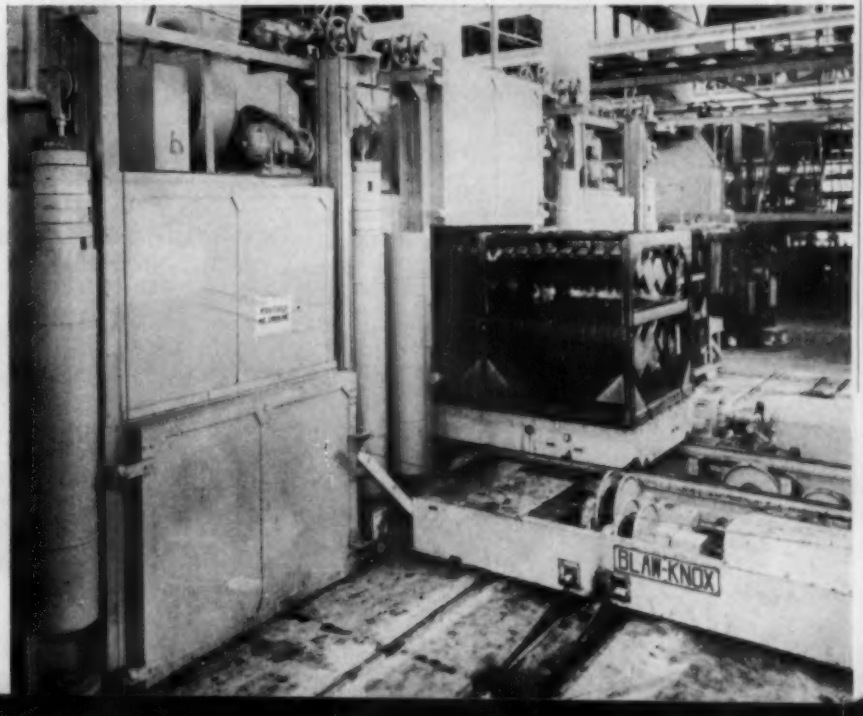
2

Control system for sequencing all operations in this multiphase process was designed by the Bristol Co.

AN AUTOMATIC batch impregnating system built and installed by the Process Equipment Department, Blaw-Knox Co., for a General Electric transformer plant, is now in operation. Key element in the system is a remotely controlled car with a traversing carriage that loads, discharges, and transfers racks of transformers through several stages.

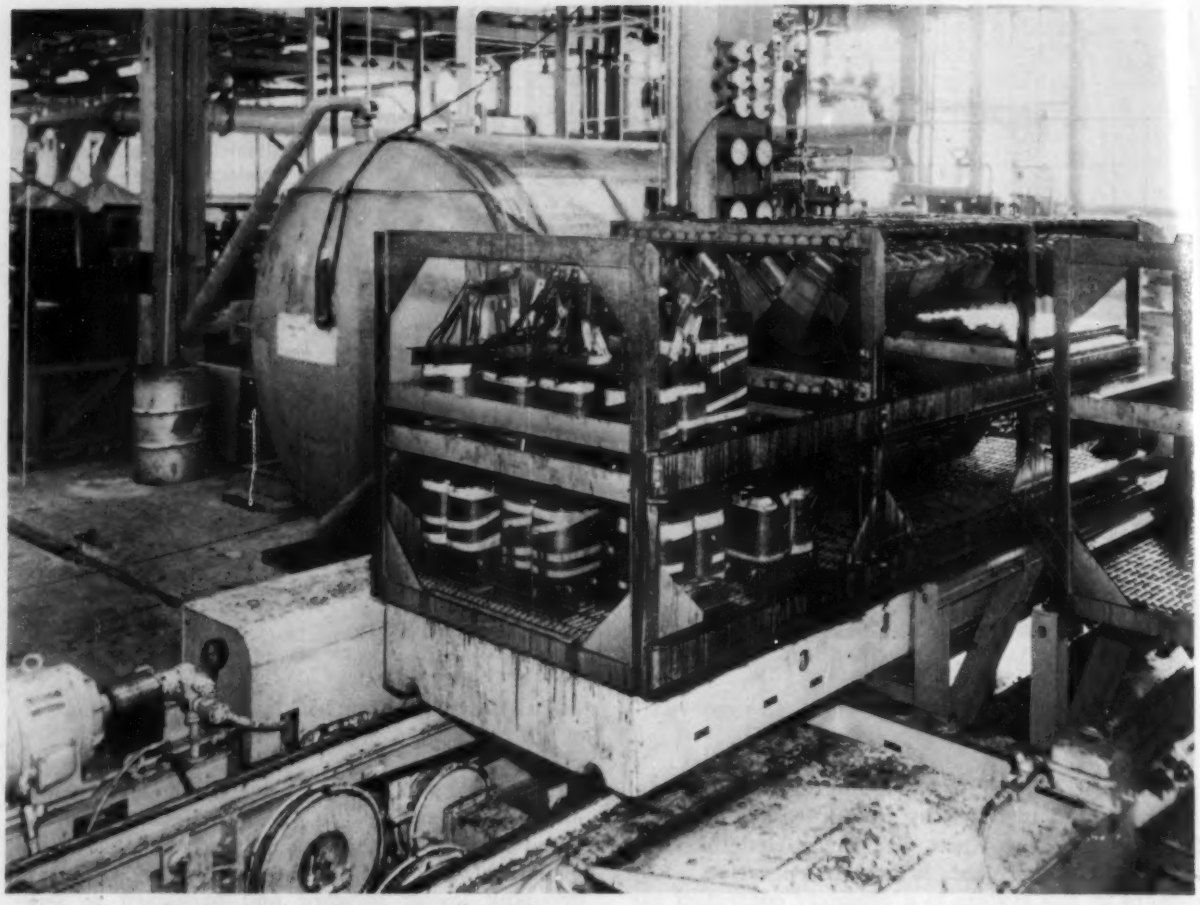
After transformers are loaded on pallets by electric hoists, the car picks up the rack or pallet and transfers it to an oven for preheat. Continuing through the cycle, the car transfers the pallet of transformers from the preheat oven to the impregnator, out again after impregnation, and then to an oven for curing. In order to transfer the material through the system the car must have 3-dimensional motion: Up and down for picking up and dropping loads; forward and backward to position the load in front of racks, ovens or the impregnator; and a traversing action which permits loads to be moved into or out of these ovens, the impregnator or racks.

This action is made possible through a car and carriage arrangement. The car travels forward and backward on a set of standard rails set in concrete and running parallel to the alleyway between



3

A pallet being removed from a curing oven. The car has stopped in front of the oven; the carriage has gone into the oven and picked up the load. Automatically, the carriage returns to its position on top of the car with a load of transformers. All car motivation is effected through three hydraulic motors. Positioning of car and carriage is accurate to ⅛-inch

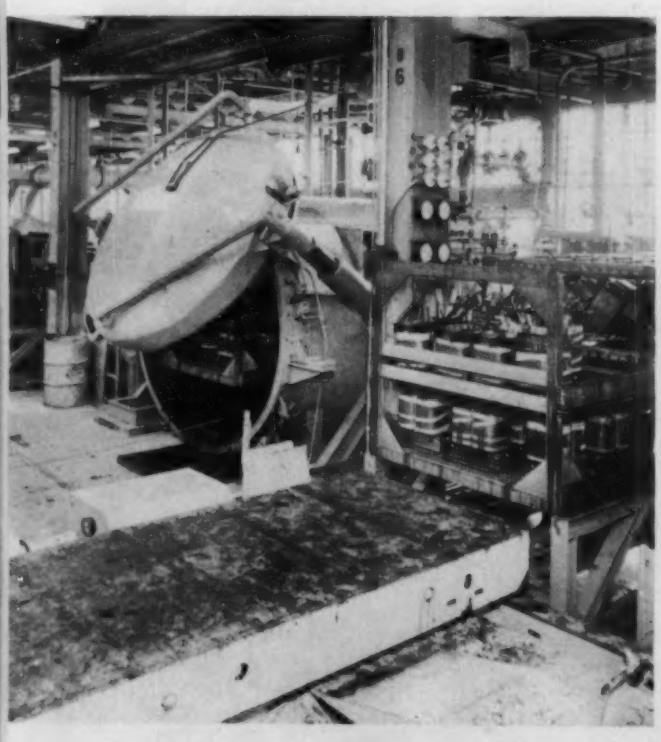


4 The pallet is transferred to a standby rack to free the carriage of its load. This particular load of transformers has been varnished and cured

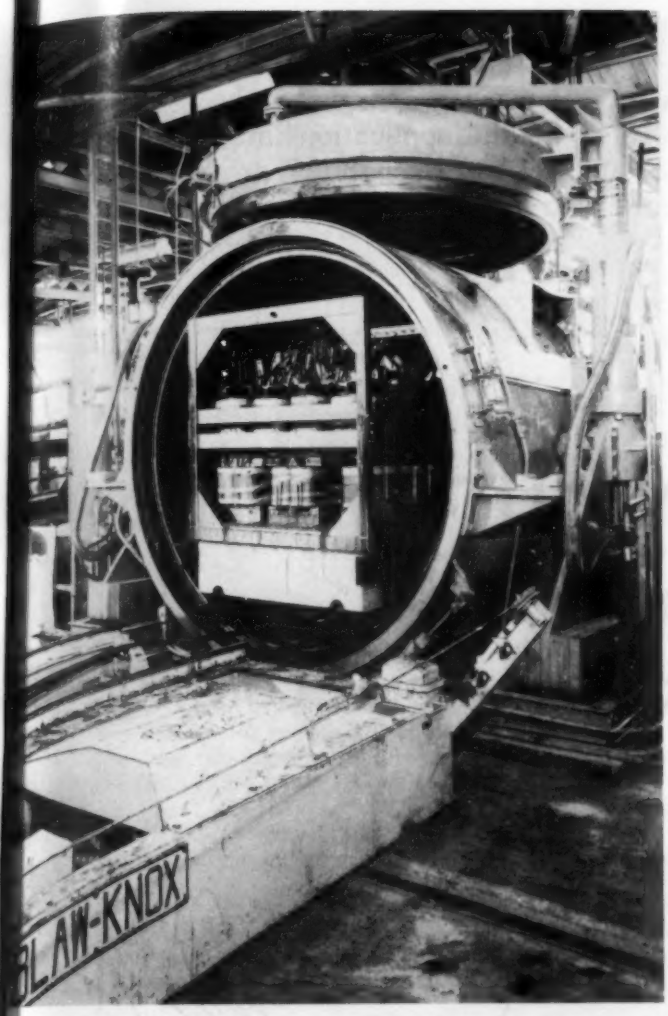
the impregnator, three-oven bank, and load and discharge stands. Traversing action is accomplished through a carriage, mounted on rails atop the car. The carriage bed is lifted and lowered through a set of four hydraulically operated screw jacks.

All car and carriage motion results from three hydraulic motors which are powered by a 5 hp electric motor connected to the hydraulic pump. As a safety feature, the car is equipped front and rear with waist high cables which will stop car and carriage motion when pulled or pushed.

Each of the three ovens, the impregnator, and rack stands have built-in rail runways for the carriage. A gap of two feet between the rails on the car and the rails in the racks and processing units is bridged by the wheel arrangement on the carriage. Four sets of trucks under the carriage keep it in balance even though one set of wheels is off the rails during transfer.



5 About 4000 gallons of varnish have been pumped from the impregnator before the door automatically opens. The car is now free to pick up the load in the impregnator after placing its previous load in the standby rack



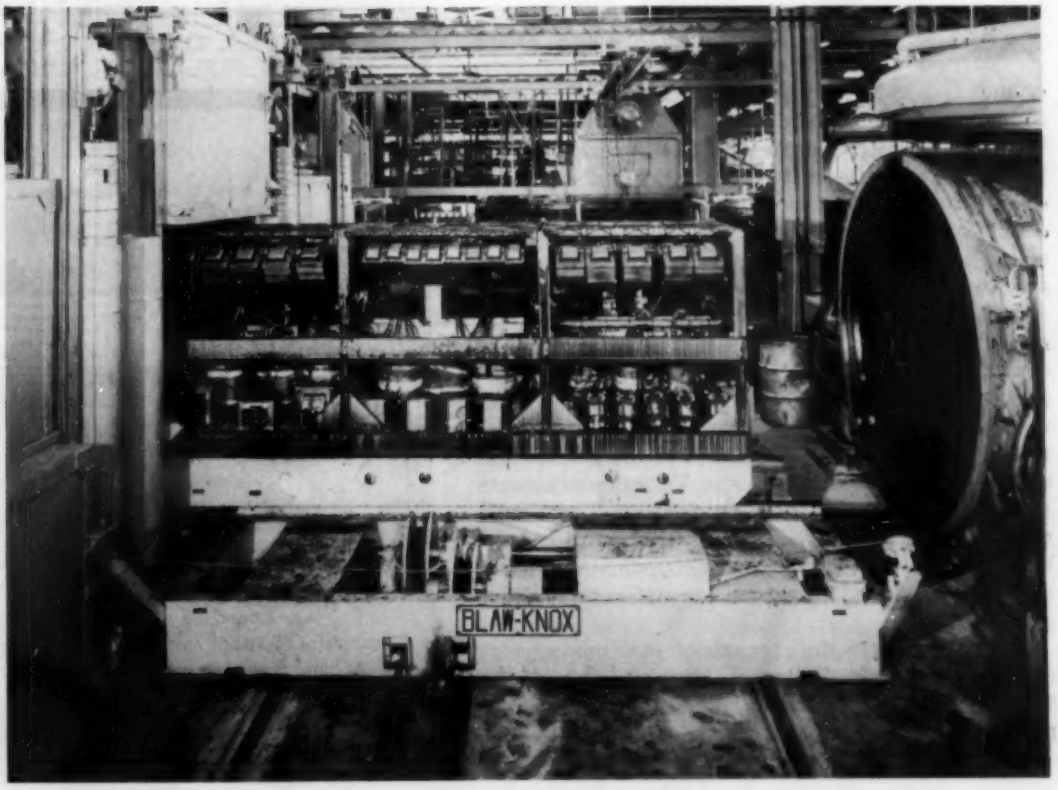
6 In removing a load from the impregnator the transfer carriage has engaged the load in the impregnator. The car weighs 20,000 lb and will carry a load of 12,000 lb. It travels at ½ foot per second

The impregnator has a 7-foot, 6-inch inside diameter and will operate at pressures up to 135 pounds per square inch. Its quick opening, automatically controlled door opens by moving horizontally away from the vessel and then traversing upward where it rests flat against the top of the vessel.

Three ovens built by Young Brothers, used for curing and preheating, are equipped with automatic telescoping double doors, and two systems of air circulation within the ovens. One system circulates hot air which dries the varnish, forming volatile solvent vapors. The vapor concentration must be held below the flash point, so a system for fresh air intake is incorporated in the oven.

Electrical controls designed by the Bristol Co. keep all operations and motions phased automatically.

7 The load from the impregnator is shifted directly across to the first curing oven, which was vacated when the cycle began. After discharging this load, the car picks up the pallet in the standby rack to move it out of the system



Maintaining complex electronic circuits has never appealed to the practical production man. However, potential applications may be stimulated by the possibilities and requisite reliability provided by transistors, kinds and basic characteristics of which are discussed in this article

TRANSISTORS IN AUTOMATION

RELIABILITY INSURES ROLE FOR ELECTRONIC CONTROL

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SEVEN YEARS ago, the *New York Times* carried a small announcement by Bell Telephone Laboratories of the discovery of a new component which is probably the most spectacular in the history of electronics. The American scene had been introduced to an application of solid-state physics in the form of the germanium point contact transistor. Since that date the development, technology and manufacturing skill associated with transistors has pyramided rapidly.

In 1951, Bell Laboratories announced a second major development having a much wider range of application and greater reliability than the point contact transistor—the germanium junction transistor, *Fig.* 1. This was followed by an announcement in 1954 by the Philco Corp. of the germanium surface barrier transistor, and Texas Instruments Inc. of the silicon junction transistor. The silicon transistor increased the high-temperature and, at the same time, higher frequency applications heretofore limited in transistors manufactured from germanium.

Application of the transistor to commercial equipment rapidly followed device development. The Sonotone Corp. placed the first transistorized hearing aid on the market late in 1952; the Regency division of IDEA produced the first commercial

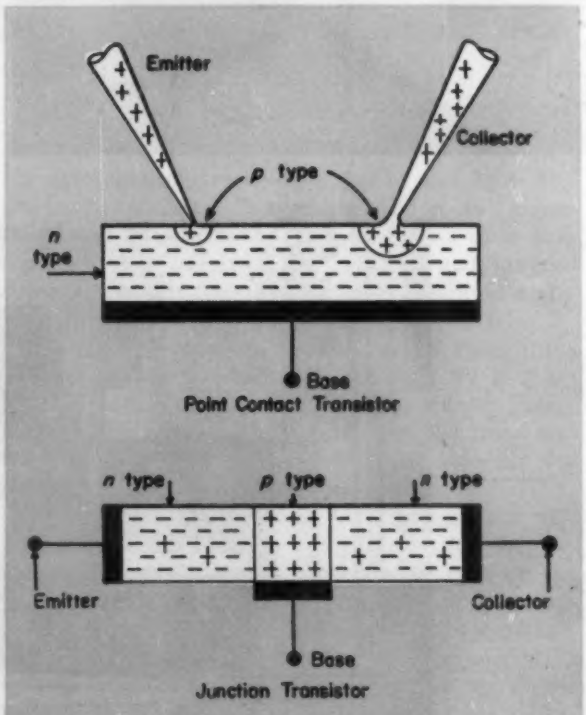


Fig. 1—Point contact transistor (top) was first form developed by Bell Telephone Laboratories. An improved form, the junction type transistor (bottom) with wider range of applications and greater reliability was subsequently developed

Fig. 2—Radio designed by Regency division of IDEA was one of first commercial applications of transistors. The four transistors used are shown in rear view of chassis

radio in the latter part of 1954, *Fig.* 2. Almost every equipment manufacturer utilizing any form of electronic device quickly set up groups to study the application of the transistor to existing or proposed designs. Many, such as IBM and RCA, built prototypes utilizing transistors.

The vast effort expended by industry has had one particular point in mind—the justification of replacing the vacuum tube, which has 30 years of improvements behind its present form today, with the transistor, which has been known only seven years and which has been a developed commercial component only since 1951. Reliability studies of equipment using transistors have justified the investigative cost and the immediate future will see increased transistor applications in a great many areas formerly covered by the vacuum tube and in others where the vacuum tube could never be applied, *Fig.* 3. Such an area is the field of automation, where the value of new equipment utilizing the vacuum tube is rapidly reaching a point of diminishing return in the sense of reliability, cost of maintenance, and power required.

▶ Control Impurities for Characteristics

The transistor is made from materials of a class know as semiconductors. The principal semiconductor materials used today are germanium and silicon, *Fig.* 4. Adding small controlled amounts of other materials to a semiconductor will cause it to conduct because of either an excess of electrons or a deficiency of electrons. Therefore, in order to provide a basis for exact control of the required impurities introduced to produce transistor action, it is very necessary that the starting material used for manufacturing transistors be very pure. The necessity for high purity has resulted in development of the zone refining technique in which a bar of the material to be used is passed slowly through several molten heat zones, *Fig.* 5. The impurities in the material prefer the molten state and tend to remain in the molten zones and

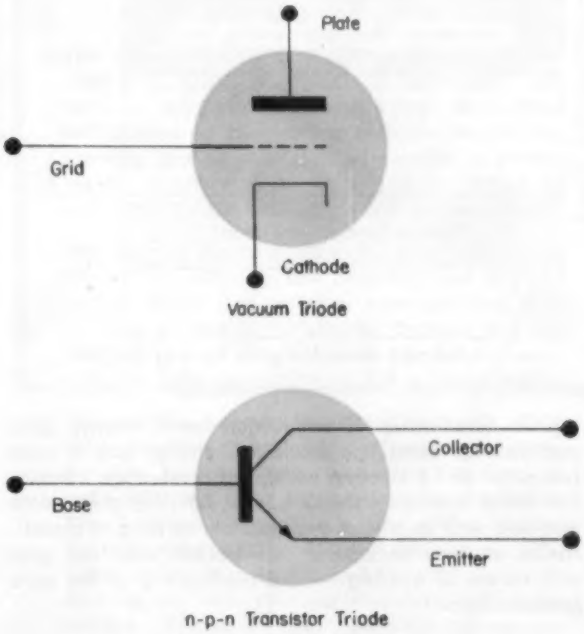


Fig. 3—Schematic diagram suggests the comparative features of simple vacuum triode and transistor triode. Transistor may be used in applications as an amplifier, a mixer, oscillator, switch and a detector

"tail out" at the end of the bar. The refined material is polycrystalline.

A transistor structure is made by the addition of certain impurities to the highly pure semiconductor material. Since any polycrystalline interfaces present an obstacle to controlled movement of the electrons, it is necessary to manufacture the transistor from a single crystal. The crystal is grown in a crystal puller at the same time the impurities are added.

Semiconductors used for transistors have a valance of four closely bound electrons in an outer orbit. If small amounts of Group Five elements such as arsenic or antimony are added to the pure germanium, four of these elements form a chemical bond with the electrons surrounding four neighboring germanium atoms and the excess electron is left to wander in the material. Semiconductors which have an excess of electrons are

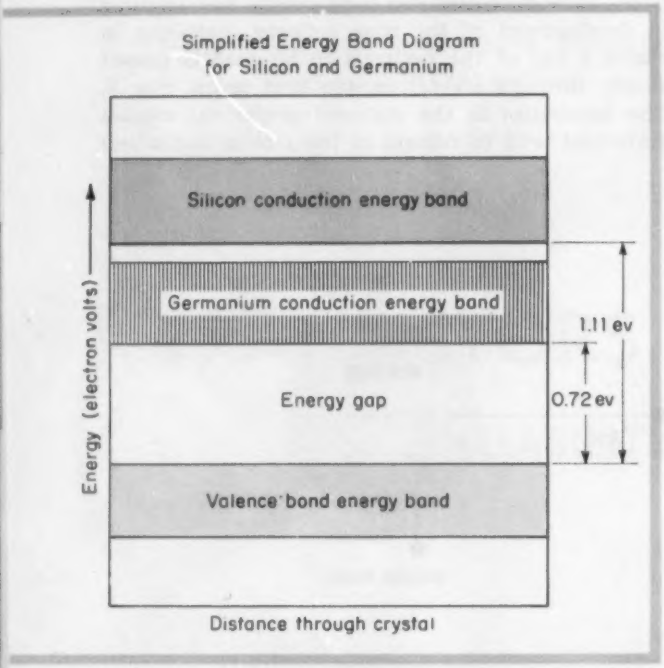


Fig. 4—Relationship of conduction band, energy gap, and valence band. In insulators, energy gap is wide (on order of 15 electron volts); in conductors, conduction band overlaps valence band. Small gap for some elements such as silicon and germanium lead to classification as semiconductors. Controlled impurities provide means of altering normal conductivity of the pure semiconductor

called "*n*-type" since the electron charge is negativ and current flow will take place by movement o the electrons.

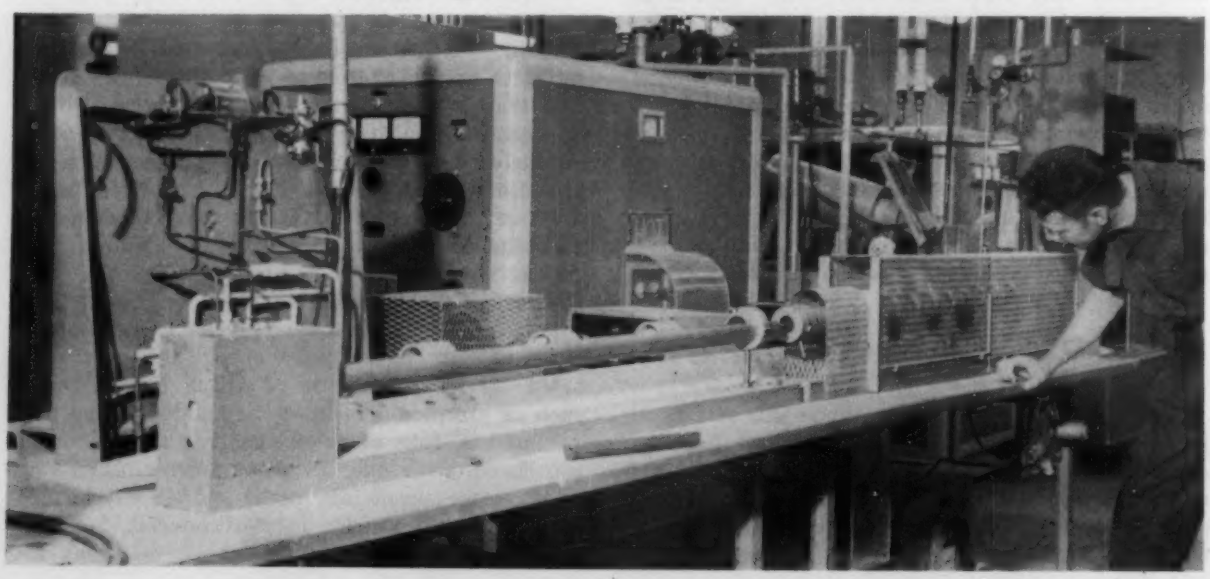
If the impurity added is from Group Thre metals such as indium or gallium, the three oute electrons form a chemical bond with the electron of the three neighboring germanium atoms, leavin one bond unfilled. This unfilled bond is by defini tion called a "hole" and behaves as a positively charged carrier. Semiconductors with these types of impurities are called "*p*-type" since the conduction is by positively charged holes.

In a *p-n* junction, if voltage is applied such that the positive end of the source is attached to the *p* type (electron deficient) and the negative end to the *n* type (excess electrons) then the electrons will move across the junction to the positive terminal and the holes will move across the junction to the negative terminal. Thus we have very little resistance to current flow. The *p-n* junction is said to be biased in the forward (low impedance) direction. If the negative terminal is attached to the *p* type material, then the movement of electrons and holes is away from the junction and there will be very high resistance to conduction. The *p-n* junction is then biased in the reverse (high impedance) direction, *Fig.* 6.

The transistor is a triode consisting of three sections of impurities. These may be *n-p-n* or *p-n-p* regions. It is a device for obtaining an amplification of power and to illustrate the physical operation, let us consider the *n-p-n* transistor.

The three regions are named the collector, *n*; base, *p*; and emitter, *n*. The emitter-base junction is biased in the forward direction (low impedance) such that electrons move from the emitter to the base. They then pass through the base. The collector-base junction is biased in the reverse direction (high impedance) so that the electrons that pass through to base are attracted and collected by the positive potential at the collector.

Fig. 5—Requisite purity of germanium is obtained in process in which bar is passed through several heat zones in which metal momentarily reaches molten state. Harmful impurities tend to remain in the molten zone and are eventually concentrated at the end of the bar



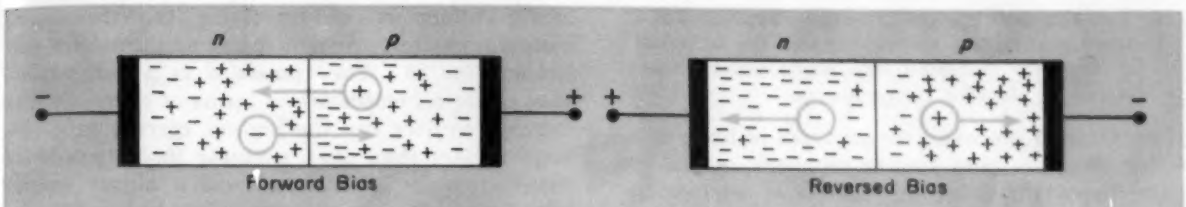


Fig. 6—Effect of voltage applied to *p-n* junctions. If junction is biased in forward direction there is little resistance to electron flow; reversed bias results in high resistance to conduction

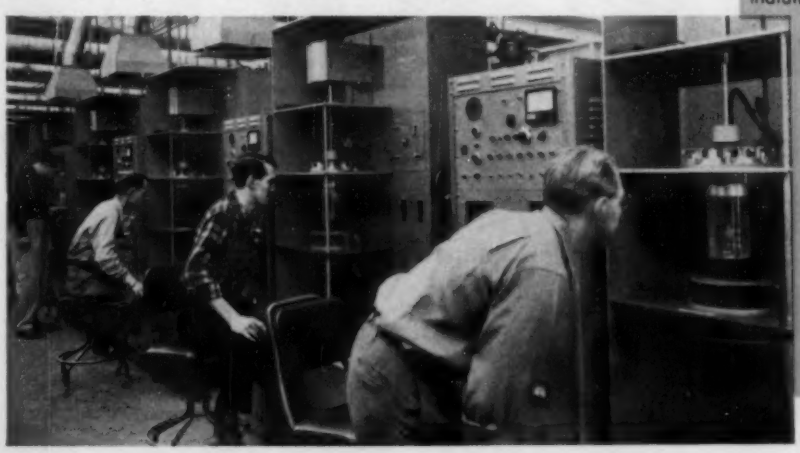
If the input power is varied by a signal with information, then the output power is an amplified reproduction.

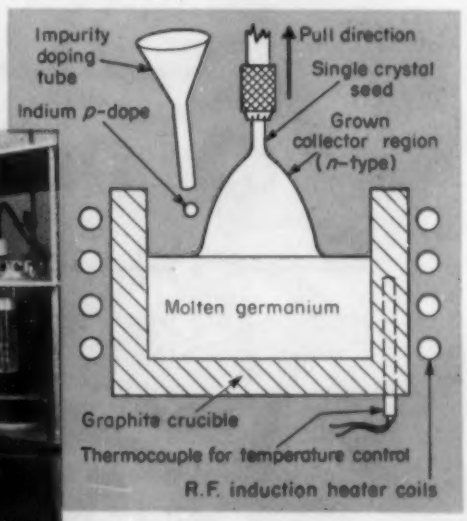
▶ Manufacture of Transistors

The are currently five methods used to obtain transistors from semiconductor material. All methods vary somewhat and the characteristics of transistors manufactured from these processes vary accordingly. They are:

1. The grown junction method. The transistor properties are introduced by doping molten germanium with proper impurities while allowing the single crystal to be formed. The crystal formation is brought about by freezing the molten germanium on a single crystal seed while slowly withdrawing the seed from molten metal, *Fig. 7.* Since the middle or base layer width has to be very small, this method is extremely dependent upon the temperature of the molten material and the rate of withdrawal. Only one junction crystal is made in this method.
2. The rate grown method. This process of obtaining a junction crystal is essentially the same except both the *p* and *n* type impurities are present in the molten material before the growing process starts. The junction is grown by an impurity segregation process which is controlled by the rate of growth of the crystal.
3. The alloyed junction method. The junction is formed by alloying the collector and emitter regions into a thin wafer of base material, *Fig.* 8. This is done in an alloying furnace and the alloying process depends upon the temperature and the rate of cooling of the alloyed wafer.
4. The surface barrier transistor method. This method, although basically performing the same function of forming a transistor junction, is quite different from those previously described. The starting material is a thin wafer similar to that used in the alloyed technique. The width of the base is attained by electrolytically etching the base starting material with a jet stream. The emitter and collector regions are then placed on each side of the base by an electrolytic plating technique utilizing the same jet stream, *Fig.* 9.

Fig. 7—Molten germanium freezes on crystal seed to form single crystal in grown junction and rate grown method of producing transistors. Specialized nature of work is indicated in photograph showing array of crystal pullers at Texas Instruments Inc.





5. The diffusion method. Junction transistors are fabricated by this method through the diffusion of impurity materials into semiconductor materials at elevated temperatures.

Fabrication processes for all types of basic transistor structure pose similar problems, one of the more important being the control of surface impurities. This is a vital factor which affects the reliability of the device. Moisture is also a detrimental factor present in the manufacture of transistors.

Limitations and Circuits

Principal limitations of transistors have been at high temperatures, high frequencies and high power levels. Germanium transistors will operate at 75C when proper circuit design is utilized and there have been demonstrations of operation at 100C. The silicon grown junction transistor will operate at 150C. Most production to date has been on transistors that have frequency responses in the range of 0 to 30 mc. Satisfactory power devices have operated up to a range of 10 to 20 watts.

Transistors may be used in virtually all types of application where vacuum tubes are used. This includes application as an amplifier, a mixer, oscillator, a switch, and a detector. There are three configurations of use involving the transistor common emitter, common base, and common collector, *Fig.* 10. The transistor is a current device, hence all biases are in terms of current. The common emitter has the highest current gain (always greater than one), a higher input impedance (approximately 1500 ohms) and a higher output impedance. The input signal is always 180 degrees out of phase with the output signal.

In the grounded base amplifier, power gains obtainable are somewhat less than in the common emitter. Current gain is always less than one, the input impedance is low (50 ohms) and the output impedance is high (1 megohm or greater). This connection requires two sources of bias power and for this reason is usually not used—the common emitter connection being favored.

The common collector can be applied as a cathode follower and a detector. Like the vacuum tube, its use as a cathode follower has a voltage gain less than one. Usually 10 to 14 db power gain can be obtained and a high input impedance, which is dependent upon the emitter load, is possible.

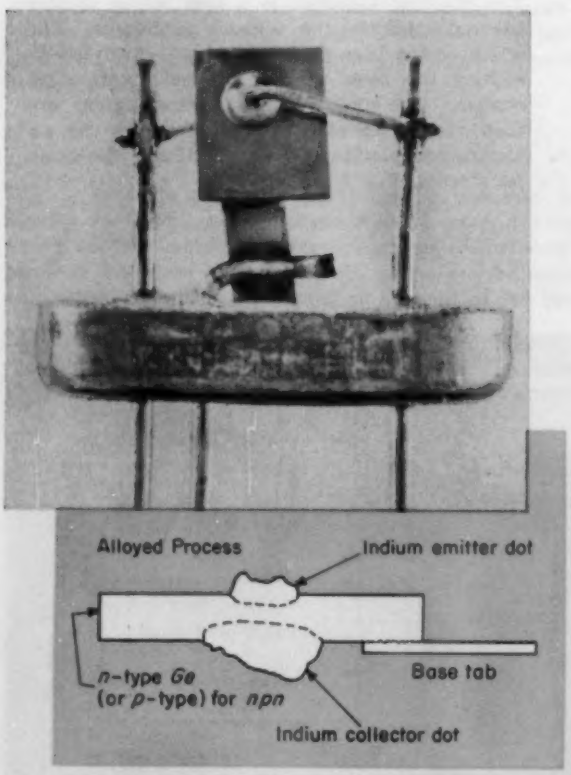


Fig. 8—Junction in alloyed process is formed by alloying collector and emitter regions into a thin wafer base material. Photograph shows internal structure of *p-n-p* alloyed germanium transistor

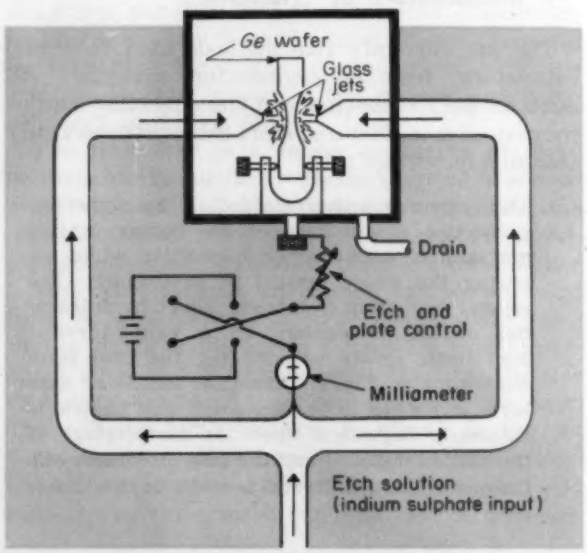


Fig. 9—In surface barrier method, thin wafer of starting material is etched to proper thickness with a jet stream. Subsequently, an emitter and collection region are formed on the wafer by electrolytic plating technique

Commercial Applications

The possible applications of transistors are numerous. A partial listing of the broad areas of applications are:

1. Highly reliable, durable automatic production control equipment.

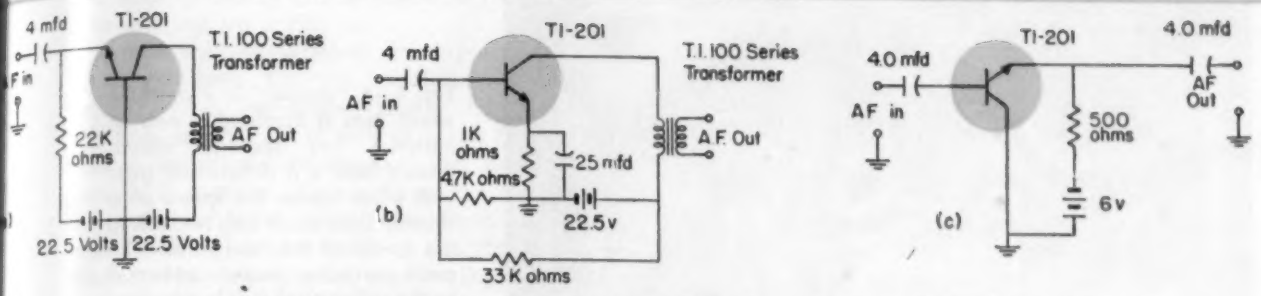


Fig. 10—Using a *n-p-n* transistor in the circuits, these diagrams illustrate the three usual configurations: *(a)* common base, *(b)* common emitter with temperature stabilization, and *(c)* common collector

2. Receivers and transmitters.
3. Digital and analog computers.
4. Military electronics equipment and systems.
5. Hearing aids.
6. Test equipment.

Many other applications are in various stages of design. Transistors for high-speed switching application have recently been placed on the market in commercial quantities. The advent of high-speed switching transistors makes transistorized computer designs practical. Experimental computers such as that by IBM shown in *Fig.* 11 have already been built and evaluation of transistors for computer life and reliability have been under way for several years.

The use of electronic computing devices as control elements in the automation of certain manufacturing processes is much nearer to reality with the acceptance of the transistor as a component. Interested management and engineers in continuous-flow process factories feel that 100 per cent reliability per year is necessary for any computer device controlling these processes. This is not impractical for transistorized computers. The power requirements for transistors are small. Individual assemblies can be completely capsulated, allowing incorporation into systems where the atmosphere is explosive or toxic. In designs utilizing transistors, the building blocks are small and physical space limitations can be radically reduced.

Cost of germanium transistors dropped sharply in 1954 from approximately $8.00 to $3.25 in sample quantities and to as low as $1.50 for transistors in production quantities. This healthy, competitive industry expects to see transistors selling competitively with tubes as markets increase within the next two years. The availability of progressively less expensive transistors will in turn expand applications to many other commercial uses.

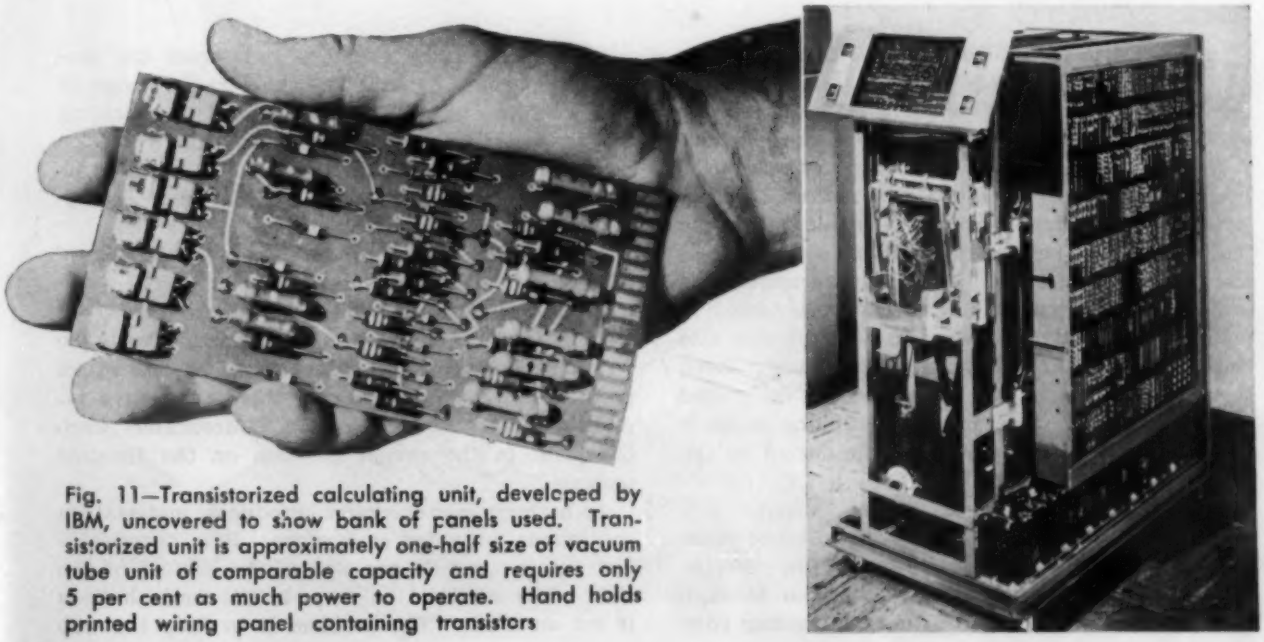


Fig. 11—Transistorized calculating unit, developed by IBM, uncovered to show bank of panels used. Transistorized unit is approximately one-half size of vacuum tube unit of comparable capacity and requires only 5 per cent as much power to operate. Hand holds printed wiring panel containing transistors

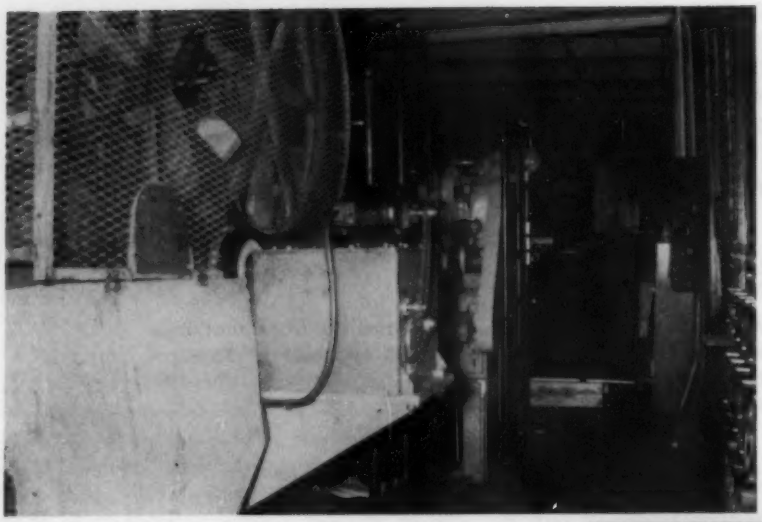


Fig. 1—A "sheeter" is a machine which cuts a continuous web of material into separate sheets. Shown here is a differential gear unit which varies the speed of a sheeter knife shaft with relation to the speed of the feed rolls. The small correction motor connected to the differential unit is selectively operated to advance or retard the knife shaft rate of rotation

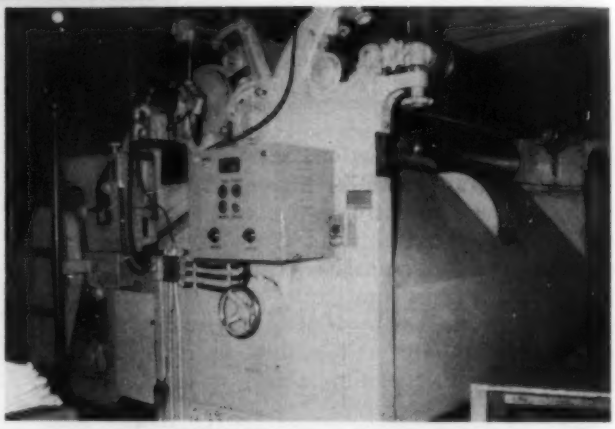


Fig. 2—Operation of the correction motor in *Fig.* 1 is controlled from the panel in center of this picture. Photoelectric scanner partially shown at top center, sends impulses as register points on the web are sensed. Selector switch, shown in box, is directly coupled to knife shaft. Relative timing indicated by these units is translated by electronic control circuit into desired operation of correction motor

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CONTINUOUS REGISTRATION

CONTINUOUS PROCESSING of materials frequently involves problems in control of registration between the moving material and the actions of the equipment and feed mechanisms.

A steel company lithographs an entire coil in making such items as bottle caps instead of lithographing individual sheets. Punching out the individual caps so that the print is centered is thus a problem. As the steel is lithographed it is coated, heated, cooled, stretched and distorted in many ways. Gage variation in the web can also cause variation in web tension and speed. Even if the feed on the punch press could be geared exactly to the repeat of the lithographing, it could not be held in exact relation to the design on the web.

A roofing company feeds siding "boards" into a machine that coats them with asphalt and stone granules. Feed rolls on the machine receive boards from a conveyor and push them through the machine. It is essential that the leading edge of each piece enter the feed rolls from the conveyor in proper contact with the trailing edge of the preceding piece. Any overlapping or buckling means waste material, and any space between boards results in asphalt and stone granules on various parts of the machine and can cause a stoppage of several hours for cleaning.

A breakfast cereal producer wraps his box of cereal with a printed paper overwrap. The overwrap is printed in continuous strips and is cut from this continuous web in conjunction with the wrapping operation. Appearance of the packaged product is very important in this competitive industry and so the problem is to accurately keep the print in the proper position on the finished package.

A battery manufacturer produces material in continuous webs for separators. Ribs spaced $\frac{5}{8}$-inch apart cover 20 per cent of the surface of the web. The material is very brittle and shatters if cut on a rib. The problem is to keep the web

and knife properly synchronized so that the knife does not cut on a rib.

A producer of window envelopes processes a continuous web for the windows. The web is printed, oiled for transparency, dried and then cut into sheets. This web is three hundred feet long from printer to sheeter, and in the drying process it shrinks. Feed rolls on the sheeter must be slowed to take care of this shrinkage so that web tension does not build up and the web break. Feed to the sheeter must also be kept in register.

▸ Means to Maintain Registration

First requirement for solutions to problems of registration or synchronization, including those already mentioned, is that speed of operation or feed in one part of the process be adjustable in relation to the speed of other parts.

There are several methods which can be used in meeting this requirement. One is the use of a gear type differential in the drive of the element to be varied. Another is the use of a clutch arrangement in this drive. A third method, used particularly with rack and pinion type drives, is to advance the pinion one or more teeth with a solenoid while the rack is disengaged.

One of the most versatile methods is the use of a differential, and that method has been applied in each of the different examples quoted at the beginning of this article. At the steel company the feed rolls of the punch press are driven through a differential arrangement which increases or decreases the speed of the rolls as needed to maintain register. At the roofing company the speed of the conveyor is adjusted. Similarly the cereal producer, the battery manufacturer, and the envelope maker use differential arrangements to vary speed of feed rolls. In other installations it is sometimes desirable to maintain constant web speed and vary the speed of operating elements such as the cutter knives on sheeters. *Figs.* 1 and 2 illustrate a sheeter installation with register control by regulation of knife speed through a gear differential.

After means are provided to allow adjustable variation of speeds between parts of a process, considerations of quality, economy and rate of processing usually indicate the desirability of providing for automatic sensing and adjustment of register. Here again there are several possible methods. A method successfully used on the applications cited, and illustrated as part of the feed roll control system sketched in *Fig.* 3, utilizes a photoelectric scanner. Such scanners may be triggered by register marks, leading edges or trailing edges of pieces, or even irregularities in thickness as on the battery separator line. Photoelectric scanners may be actuated by either transmitted or reflected light.

▸ A Specific Synchronization Solution

Sketched in *Fig.* 3 is a complete system to control registry on a sheeter by variation of feed roll speed. On a standard sheeter the feed rolls would be geared directly to the rotation of the cutoff knives. In this installation the drive of the feed rolls is through a differential gear arrangement sometimes called a correction transmission. Speed of the feed rolls is advanced or retarded with relation to that of the cutoff knives by selective operation of a correction motor connected to the differential unit.

Register marks or other reference points cause signals to be sent from the scanner to the control

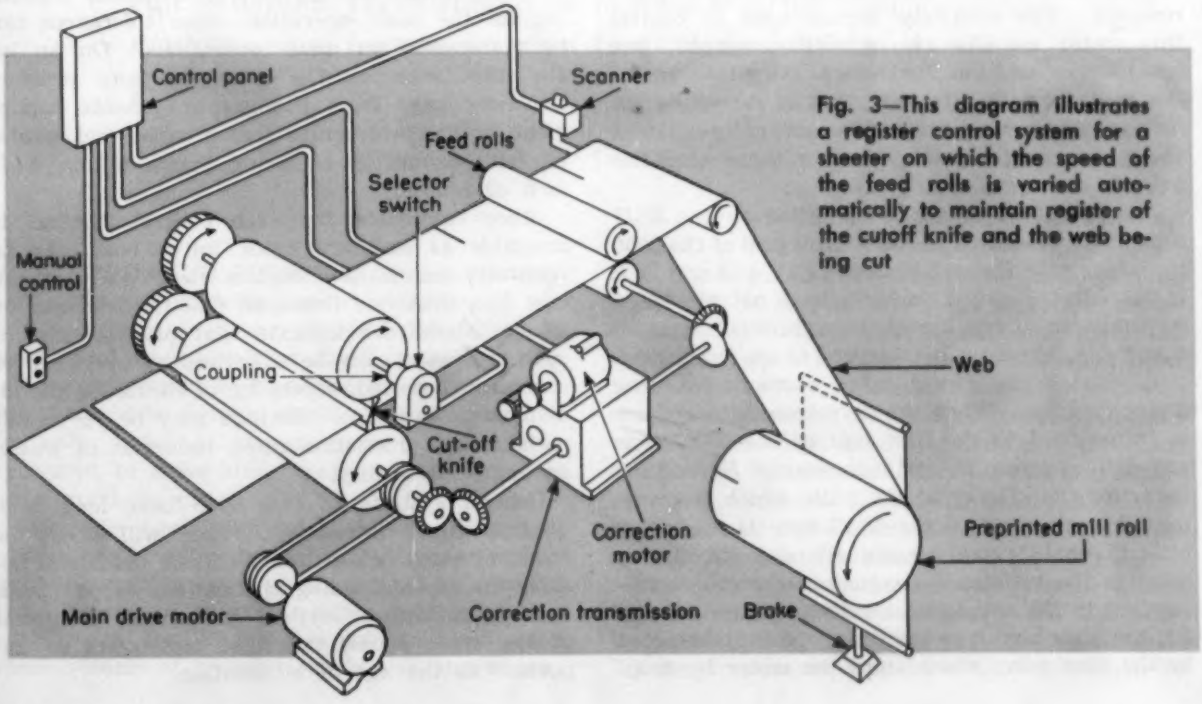

Fig. 3—This diagram illustrates a register control system for a sheeter on which the speed of the feed rolls is varied automatically to maintain register of the cutoff knife and the web being cut

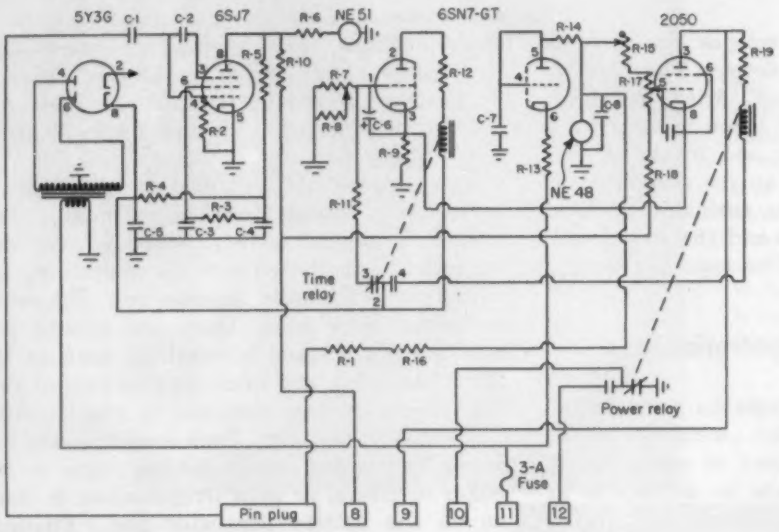

Fig. 4—Schematic wiring diagram for one of the plug-in amplifier units used in the register control system shown in *Fig.* 3

panel. A rotary selector switch with a neutral zone is mechanically coupled to the cutoff shaft and continuously establishes a reference as to when cutoff has occurred, will occur or is occurring. If the selector switch is in its neutral zone when the impulse from the scanner is received, the web is indicated to be in register and no correction is made. If the selector switch has passed its neutral zone when the scanner impulse is received, the correction motor on the differential gear unit is operated in the direction which causes the feed roll speed to be increased. If the selector switch has not reached its neutral zone, the opposite correction is made.

In the system diagrammed, the correction motor is operated on dc and designed for full capacity starting action, noncoasting stops and rapid reversal. The electronic circuit used to control this motor includes two amplifier systems, one for advance and one for retard. Separate amplifier systems with different rates of correction for forward and reverse are used to prevent oscillation about the control point. One of these amplifier units is diagrammed in *Fig.* 4.

The phototube signal is amplified by the 6*SJ*7 tube and transmitted to the control grid of the 2050 thyratron tube through resistors *R*10, *R*18 and *R*17. If the selector switch contacts have not prevented transmission of the signal through circuit connection 8 the thyratron is triggered to its firing position, closing the power relay contacts to cause motor rotation. When the thyratron fires, a pulse is transmitted to the first half of the 6*SN*7 tube and divides across the cathode resistor *R*9 and the capacitor *C*6. Decay of the pulse which is transmitted to the grid of the 6*SN*7 tube is controlled by adjustable potentiometer *R*7 and *R*8. At a point in the resistance - capacitance curve corresponding to the setting of the time control *R*7 and *R*8, the plate circuit to the thyratron is interrupted by the time relay which stops the motor by dropping out the power relay. With the thyratron current stopped, the voltage developed across the 6*SN*7 tube cathode resistor is eliminated and conduction of the first half of the 6*SN*7 is resumed. This results in the time relay picking up again, giving nearly instantaneous reset in readiness for motor control should a second signal be transmitted and the above sequence of events repeated.

Sensitivity adjustment is obtained by the setting of the potentiometer *R*17 which adjusts the grid bias of the thyratron tube and permits firing of the amplifier with either a smaller or larger incoming signal, as may be necessary depending on whether phototube scanning is done with reflected or direct light. The second half of the 6*SN*7 tube places a rectified dc voltage across the phototube.

While accuracies vary to a great extent depending on the basic operation, close tolerances can be maintained on many operations. On an installation such as the steel company problem punching caps from lithographed sheets, equipment with a correction transmission and photoelectric scanner is centering prints within 0.01-inch of center.

Since equipment for such control systems is available as standard units, initial cost may be relatively small. A complete electronic unit can cost less than one thousand dollars. Reports on some installations indicate that original cost of such equipment may be amortized by savings over a six-month period, depending of course on the individual installation. Savings may be the result of increased production rates, reduction of waste, or improved quality.

Control systems of this type have long been used in paper processing. They will surely be found of value in additional outside industries besides the cap and siding applications noted. Such application across vertical industries is typical of the cross dissemination of techniques so important to the age of automation.

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AUTOMATION IS AN ASSET

IN BANKING

In banks, where clerical procedures represent the largest cost item in the entire operation, the upward trend in volume of paperwork plus increasing labor shortages create a particularly difficult situation. These conditions provide a fertile field for automation — the harvest in relief from clerical burden should be plentiful

NO THINKING PERSON today expects electronics or anything else to wipe out all our data processing problems. Such is the nature of the clerical operation that the only panacea for any company would be a padlock on the front door. But it would be equally unrealistic to believe that the only major gains can come via electronic equipment of some kind—that no other action is really worth the effort.

Electronic equipment is the latest addition to a large bag of office tools, but only under certain specific conditions may we consider it as a useful tool. Nearly all electronic office equipment that exists today can be justified only in institutions whose volume of transactions is well above average. These products are, in effect, special purpose equipment. It may be five years or longer before electronic techniques can be made practical for really wide-spread office use. Neither at that time nor at any other, would it be logical to expect a sudden blossoming forth of electronic equipment which would result in the wholesale obsolescence of standard business machines. Mechanical equipment will always be needed for countless tasks in banks and all other institutions which require direct and immediate results.

Under these circumstances, we can ill afford any fixed ideas about electronics or, for that matter, any other kind of data processing technique. Whatever tools we may have, it will always be

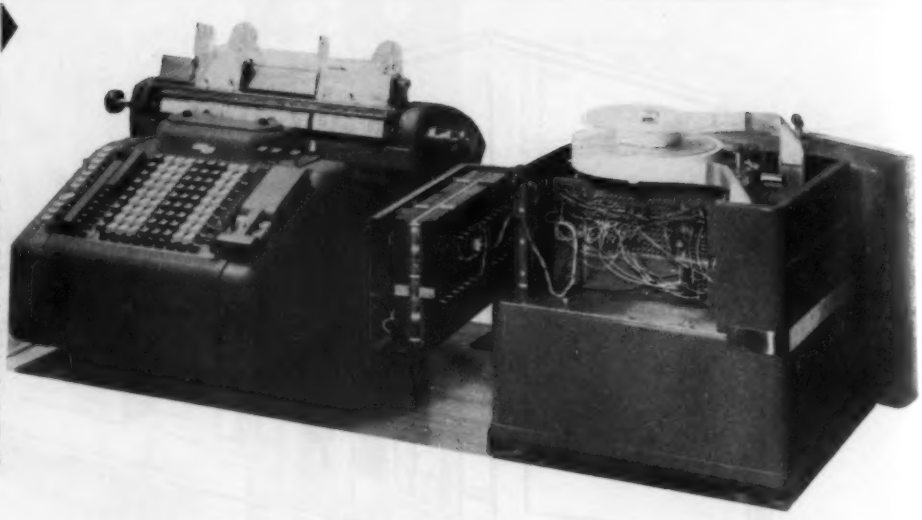


Fig. 1—Tape punching accounting machine which provides a means to punch data into tape at the point of origin as the automatic by-product of the recording operation. This system may be used in handling money orders, government checks, special checking accounts and other banking documents

necessary to consider the production of office paper work as a production type job. As in the factory, this job entails a thorough knowledge of the operation and a persistent effort to keep up with the requirements of growth.

Guard Against Obsolescence

Wherever possible, naturally, we shall want to mechanize, but our objective is not mechanization for mechanization's sake. We are certainly not interested in mechanization that might increase our costs. Therefore, we must continue, as before, to avoid mechanizing tasks that never needed to be performed in the first place. As always, we shall have to guard against reducing idle time on a machine with jobs for which better equipment is available. We must accept the essentiality of retiring equipment, whatever its age or condition, whenever new equipment can earn its keep by providing a more productive operation.

These general rules of thumb stand no matter what kind of techniques we use. Every new development in the long evolution of mechanization has served to strengthen their significance. And so it is with electronics.

Obsolescence will undoubtedly continue to be as much of a factor in the future as it has in the past. Gradually, some of it will be brought about by using the inherent characteristics of electronics for high speed, integrated operation. Some will be the result of combining electronic and other techniques. Some will be caused by mechanical considerations which continue to enhance the value of standard equipment.

Whatever the cause, however, obsolescence implies at every turn the development of a better office tool, one that will be more helpful in raising clerical productivity. If we are to be successful in realizing this objective, we must learn to live with this gradual equipment evolution. We must learn to take full advantage of the best that is available to us as it comes along.

The important thing to realize is that the job needs doing today. If we explore all possibilities, and do so continually, we will find the wherewithal to realize a more productive concept of office operation than ever before.

Equipment To Do The Job

Burroughs Sensimatic-to-Tape equipment is representative of the modern equipment available today and adaptable to banking operations. It consists of a standard accounting machine, cable connected to a tape punching device, *Fig.* 1. Automatically, as a by-product of an essential, manual operation—such as posting the amount of a savings deposit in the passbook—the tape punch creates a coded version of the transaction. This tape can then be introduced directly into the subsequent routines. If a punched card system is used, the tape can be converted automatically to punch cards. When central accounting or reporting is carried out at a different place, the tape can be mailed or sent out over teletype. It would be perfectly possible in a similar fashion, without additional labor, to create any type of media—punched cards, magnetic tape or any other that might be required for automatic handling. Many possibilities for such media come to mind in handling money orders, government checks, special checking accounts, and other banking documents. Advantages are obvious.

In the first place, the system does away with all cost associated with repetitive handling, copying, errors, and record tampering normally encountered in document processing. Secondly, because up-to-the-minute records may be posted through high-speed processing of the coded media, management has current control of departments, branches, and other sections of the bank. Many

well-known banking institutions are planning to use this system and initial installations will be made during the last quarter of this year.

Key to Bank Automation

One of the most difficult obstacles in the path of designing greater automation for banks has been the fact that a practical, acceptable system must be able to process paper checks of varying sizes. The ABA Committee on Bank Automation stressed this as a "must" in the ideal system.

To greatly reduce the labor content of the check-handling procedure, two tough problems must be solved. Because it appears that paper checks of varying size and thickness must be and should be with us for a long time, a means must be found for handling these checks automatically in sorting and tabulating, much as is now done with punched cards. It is necessary, also, to be able to read the bank routing, customer account, and amount of check automatically without requiring that the check be noticeably altered by holes, spots, or other marks.

For special documents, like travelers checks, one method is already in operation, *Fig.* 2. A large New York bank is currently field-testing a Burroughs electronic device which feeds travelers checks automatically into a scanning device, reads the numbers of the travelers checks and cuts a card to correspond. The only labor involved is loading of the hopper. The machine does all the rest, producing the desired cards at the rate of 120 a minute. Since it can produce cards, it is obviously possible to change the manner of output to accommodate punched paper or magnetic tape, or to introduce signals directly into a magnetic memory drum. The reason that this particular project is possible, of course, is that travelers checks are uniform with respect to size, shape, and print.

The problem of doing the same sort of job with regular checks, with all their differences, is very much more difficult. To read the character itself is an expensive method. We can imagine an electronic scanning device associated with each sorter, but the cost would be prohibitive. However, a document marked with invisible code, put on at the outset in the normal printing process could identify the bank and the customer. Putting the code on at the time of printing is essential, as to add cost to the document because of a separate coding operation, would offset the savings to be made from subsequent automatic handling.

Such a code would not detract from the normal appearance of the check and thus would be acceptable to the customer. Moreover, this type of code could be handled more inexpensively than reading of visible information. This approach will bring automatic check handling within the reach of many more banks than would otherwise be possible. Moreover, in addition to being able to code the fixed information at the time of printing, it will be possible to add to the document the coding of the amount in an early handling within the bank.

Presupposing, of course, that documents of varying sizes and conditions can be handled automatically, then we are close to automatic bank bookkeeping. Good progress toward the solution of these problems has been made.

The Product—Final Documents

At the opposite end of the clerical production line, creation of final documents has always been a difficult and costly task. In some respects, the final output operation is our worst clerical headache,especially from the point of view of time. Such documents as customers statements, for example, must meet a deadline. For that reason,speed of production of documents is critically important.

Over a year ago, Burroughs introduced the Series G electronic tabulating and accounting machine (See AUTOMATION, Nov. 1954). This equipment has, we believe, the fastest printing process yet developed for accounting purposes with a printing speed of 900 lines—over 43,000 characters—a minute. Equally important, this is truly an example of equipment which integrates several jobs into one. It synchronizes in one fast and simultaneous operation totaling, printing, and card punching as well. It scans two sets of punch cards, *Fig.* 3, merging the information electronically without requiring the physical merging of the cards themselves. It can be programmed to eliminate undesired cards automatically during the run; it creates up to seven clearly legible carbons; and it can be operated on the basis of a tape input as well

Fig. 2—Electronic character recognition equipment at the First National City Bank of New York reads printed numbers on travelers checks at the rate of 7,200 an hour and transfers the information to punched cards. Checks are being placed in the reader device hopper; cards are punched by the rear machine

as from punched cards. It is the first business machine equipment capable of this kind of high-speed integrated operation.

In its present state of development, the machine is finding its place in larger concerns where the volume of output is high. Various units can be assembled in different ways to accommodate requirements of a number of different applications, primarily in public utility and insurance companies, publishing and mail order houses, governmental agencies, and other large institutions.

When it becomes possible to read coded information from a check and translate it onto magnetic tape, it is reasonable to expect that the high speeds possible in this type of equipment can be applied effectively in many banking institutions. If we can punch tape as a by-product of a necessary proving or accounting operation, we can code information of amounts invisibly in a similar fashion. In short, this suggests that we have within our grasp the answer to an ultimate automatic bookkeeping system for banking institutions.

Between Input and Output

We have yet to cover the middle stage of the clerical operation—that of computation and data manipulation. The whole concept of electronics for the office stemmed initially from the electronic computer. Ever since this device became a reality for the scientific and engineering world, its potential in business computation—the middle stage of the data processing operation—was evident. As it turned out, however, computation per se has proved to be the least important consideration in developing more automatic, integrated systems.

Business computation is principally a matter of simple addition and subtraction. To increase computation speed is, of course, an attractive prospect, and the computer is certainly the ultimate in that respect. However, the major expenses of most clerical operations are not incurred in the computation area. Costs are centered in the laborious tasks of preparing the new data for computation and in transcribing the final results. The computer, as such, made no contribution to problems in those areas. Indeed, until they were solved, little gain could be expected from speeding up the computation process.

Without input and output equipment to match the speed and efficiency of the computer within a reasonable degree the high cost of one of these devices simply bought a lot of speed and power that couldn't be used. In adapting computers for office tasks, there are other problems too, such as reducing construction and maintenance costs, improving reliability of operation, and others. And it is now recognized that there are a number of clerical operations which simply do not lend themselves to automatic handling—not because electronic equipment can't be built to handle them, but because they can be done more efficiently by other means.

The fact is that the big gains to be made in stepping-up office productivity are to be found in the

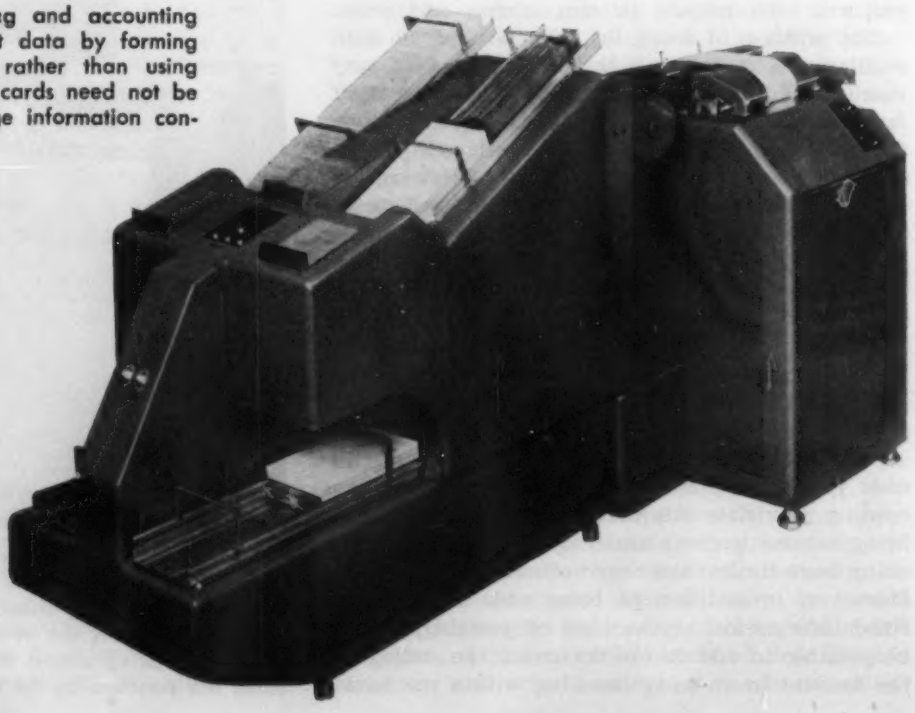


Fig. 3—Electronic tabulating and accounting machine that prints output data by forming letters of "dot" patterns rather than using type. The two groups of cards need not be merged physically to merge information contained

Fig. 4—Burroughs E 101 digital computer which operates automatically or semiautomatically so that the operator can assume those functions which are best performed manually

other two areas of the data processing operation. It is there that the bulk of our research and development effort is concentrated.

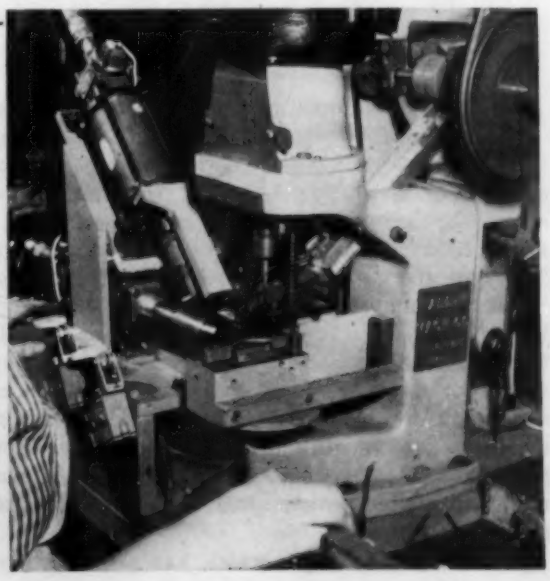
Difficulties in adapting computers to business operations are primarily problems in flexibility. None of these devices can really think. They are slaves which do exactly what they're told, and only what they're told. The little exceptions to the rule which crop up in almost any kind of problem require that specific provisions be made to handle these exceptions if operation is at all times to be automatic. This can be done, but only at a price. Accordingly, where exceptions require only a little common sense, it is far more practical to bring the operator into the act. Smaller, low-cost computers, *Fig.* 4, are designed with this end in view. The result is not only a saving in construction costs; it also opens a wider variety of applications than would otherwise have been possible.

The small, low-cost computer has extended the areas in which computers can find their niche. And it represents a marked advance toward the type of computation device which will eventually be practical for wide-spread business use. In fact, a computer evolved from this type and associated with a coded check reader and a high-speed printer, could well be a key unit in the automatic bank bookkeeping system of tomorrow.

Cost control and productivity are matters which require attention now. It's a job for today, and it can only be done with today's tools. Those tools, moreover, if put to optimum use, are capable of a higher level of savings than ever before. They will definitely continue to be a part of the office picture in the future. If in certain areas the evolution of electronic and allied techniques ultimately brings about some obsolescence, you will have no cause to regret it. It will simply be part of the same gradual trend which has caused you to replace some of yesterday's equipment with the newer products of today. In both cases, the reason can only be that a better tool has come along that can justify itself on the basis of a saving in operating costs.

If we are to succeed in improving office productivity, we must continually take constructive action which will keep us up to date. If we are realistic about the nature of the job, if we keep ourselves informed, if we take full advantage of all there is to be taken advantage of, the better office productivity we need is within our grasp—today.

Versatility Stimulates Air Motor Use



COMPLETE or partial automation of isolated individual operations can result in immediate returns for the necessary equipment investment. Typical of the type of equipment which can easily be engineered into existing setups for noteworthy results are air motors. Versatility of application of this type of unit is exemplified by an installation at Russel Industries Inc. involving the assembly of a coil to the core of a flywheel type magneto. As a manual operation, the assemblies were produced at the rate of 80 pieces per hour; with the use of three air motors supplied by the Bellows Co., the partially automated operation now produces 200 assemblies per hour.

An operator positions a coil over a core which has been placed on a fixture. One air motor pushes the coil over the core—exerting a proper pressure over an exact stroke length; a second unit, set at an angle to the work, is automatically cycled to bend over a projecting core clip which locks the coil on the core; and the third air motor is used to raise the entire fixture to a position under an automatic screw driver where a small screw is set to hold a terminal in place.

These air motors satisfy a need in industry in those many cases where some form of auxiliary power can be applied, quickly and inexpensively, to improve and upgrade an operation. The limit to the usefulness of this type of item is the ingenuity of the production engineer.

Consideration of the factors of quantity, standardization and safety in ammunition loading operations points out the desirability of automation. Successful systems offer important indirect advantages as well as the typical direct advantage of increased quality production at lower costs

QUANTITY, STANDARDIZATION AND SAFETY ACCENT AUTOMATION IN ORDNANCE

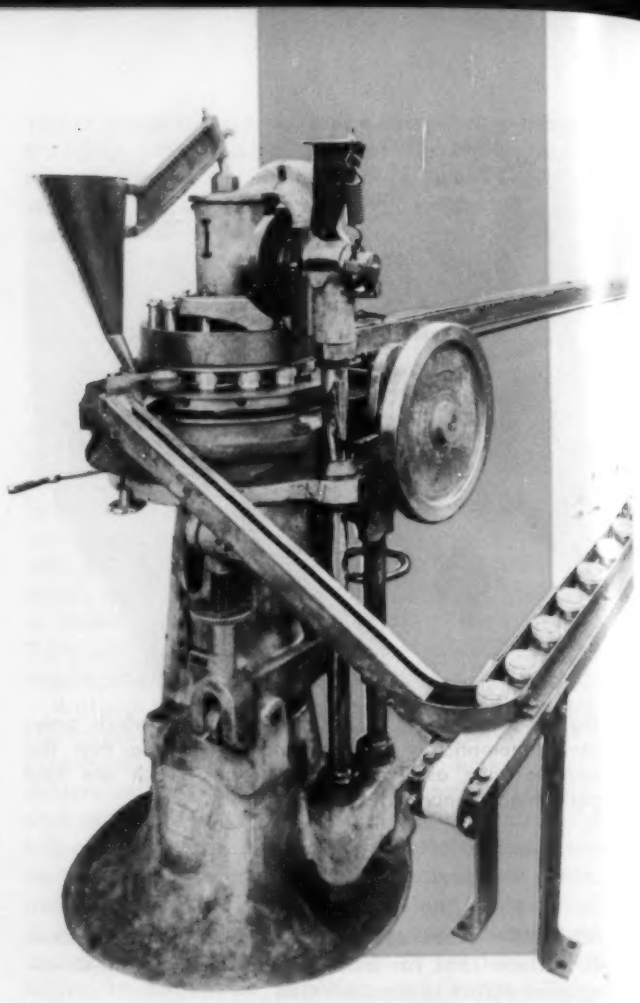


Fig. 1—Loose loading technique is accomplished on this type of press. Upper input conveyor feeds 40-mm magazines onto rotary table. Tiny lead charge of tetryl powder is pressed upward directly into the magazine by lower punches

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DESIGN of automatic ordnance equipment is a specialized field—but it is of interest to note that such design sometimes requires not only the services of specialists but also, for optimum results, the services of engineers experienced in other fields of automatic production equipment. This not too apparent relationship of seemingly dissimilar industries is illustrated by the widening area of interest of the F. J. Stokes Machine Co. From pharmaceutical tabletting machines, and with over 60 years experience in ordnance equipment the company has advanced by natural evolution into plastics molding and powder metal presses, and thence into vacuum drying, vacuum metallizing and other high-vacuum processing equipment.

The design technique which has proved successful in these fields is a simple one—a complex operation is broken down into a coherent unified scheme of separate operations to be executed in sequence. Before proceeding with the final design of a machine, the new sequence of operations, and the principles on which they are based, are thoroughly pretested by building suitable fixtures and test-loading components. In this way any new approach to solving the complex and difficult problem is fully proved. The rest is purely mechanics.

As regards ordnance equipment, with the end of the Korean emergency and the easing of the tensions that went with it, pressure from ordnance procurement offices for production at whatever cost relaxed; in its place is a new emphasis which has created a changed climate in ordnance manu-

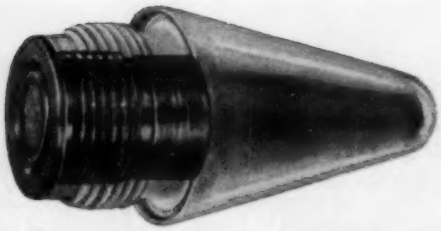


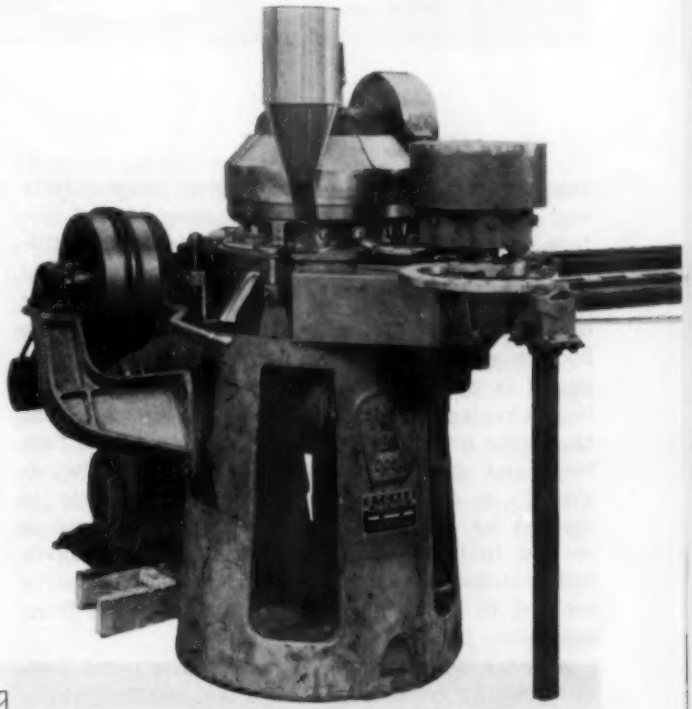
Fig. 2—Production and inspection of 20-mm fuses are completely automatic. As an example of operations performed, the booster charge, shown in phantom view of fuse, is loaded, sealed and crimped into cup automatically and in subsequent operations is automatically screwed into the fuse body

facture. Specifications are still as rigid, inspection is just as severe, but now greater attention is being paid to unit costs. Contractors are learning that they must carefully review their estimates and scrutinize more closely their manufacturing costs if they expect to retain their supply contracts. Machinery and methods that were acceptable in the earlier climate are being freshly examined with an unsympathetic eye. More and more frequently they are being replaced by designs that offer lower unit costs by integrating several operations.

In satisfying the need for more all-inclusive automatic production machinery in ordnance work, we at Stokes have noted a related tendency, deserving, I think, to be called a trend in its own right—a movement away from tabletting or pelleting explosives separately and then loading them into the shell or fuse. These operations now are frequently being combined—the powder is loose-loaded into the component and compacted therein immediately, *Fig.* 1. Both of these trends can perhaps be documented by a few examples drawn from our own designs.

Examples Illustrate Trends

One new machine designed for the automatic production of 20-mm fuse assemblies at the rate of several thousand per hour, performs 18 separate



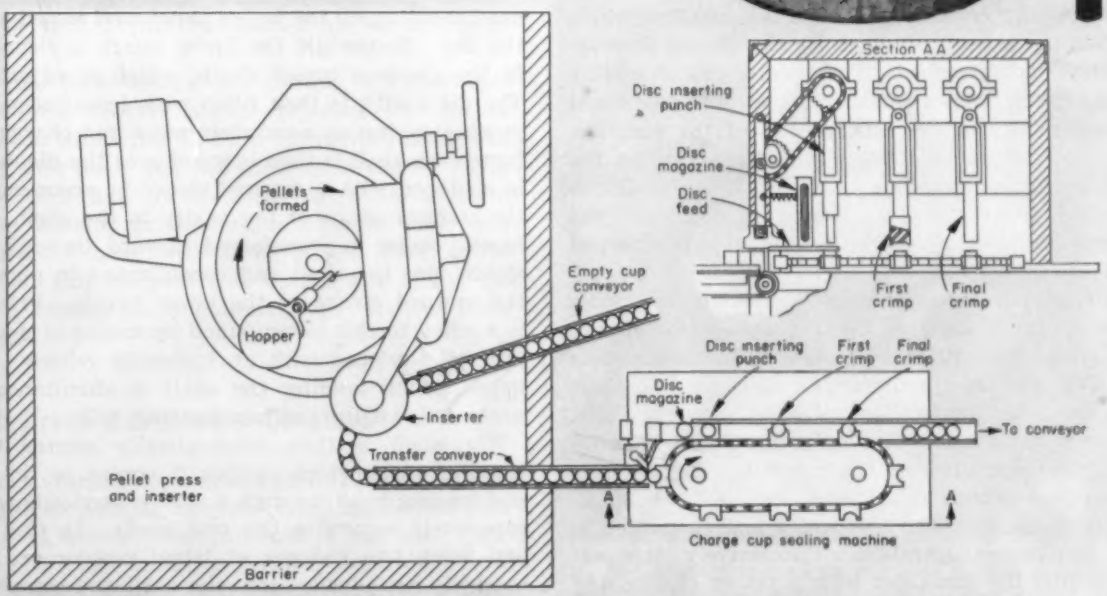
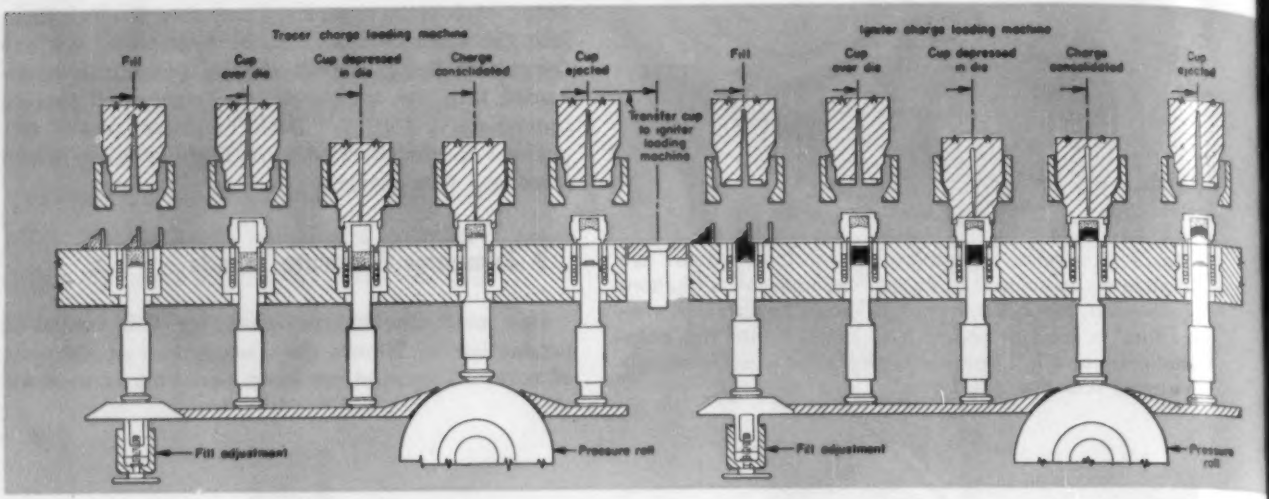


Fig. 3—Press forms tetryl booster pellets and inserts them automatically into charge cup. Subsequently the charge cup is sealed as indicated in the diagram



assembly and inspection operations consecutively and automatically. The rotor assembly of the fuse, a flat-sided ball with a detonator charge filling its cylindrical bore, is inserted automatically in the fuse body and gaged for proper positioning of the rotor, both as to depth and angle. The booster element is then inserted, a sealing compound is applied to the threads, and the booster is mechanically screwed into place, *Fig.* 2. Next the firing pin is inserted into the nose of the fuse body and gaged for position. Then the "windshield" or nose cone is added, the assembly is secured by crimping, and a sealing compound is applied to its perimeter. Final inspection, again fully automatic, completes the operation. All parts are fed to the appropriate assembly points from automatic hoppers.

Another design which illustrates the trend toward unifying several operations is a machine which makes the booster element for the 20-mm fuse assembly just described. The booster cup of gilding metal is fed from a rotating hopper and positioned automatically in the rotary head of the machine. A loose charge of RDX powder is placed in the cup and consolidated in place. Next a coil disc is blanked from strip stock and placed over the charge in the cup. Finally the cup is crimped and the completed element is ejected.

Already in use is a somewhat similar machine, developed for loading the supplementary charge for large artillery shells, which forms two pellets of TNT and inserts them automatically into their container during two rotations of the dial plate. A further refinement of this machine which we have developed, inserts the cover disc for the container and crimps it in place, *Fig.* 3. The M5A2 tracer element is also compacted and assembled in one continuous operation. Successively, the machine fills the container with a tracer charge and compacts it in place; next it fills and compacts the igniter; then it blanks and inserts a rubber gasket; next it blanks a copper disc from a strip of thin copper sheet and inserts it; then it inserts a steel retaining ring above the gasket; and finally it crimps the top, *Fig.* 4.

The three preceding machines admirably illustrate the second trend—toward loose loading of explosives and compacting them in place, rather than prepelleting. Still another new machine which applies the compacting-in-place principle has been developed for loading 20-mm ammunition—whether with a high explosive or an incendiary charge, or both. A pair of continuous motion rotary heads carries the shells through successive operations, the first head loading one type of charge and then transferring the shell automatically to the second head, *Fig.* 5.

The sequence of operations is as follows: An automatic belt conveyor with an escapement feeds the shells, one at a time, into the first loading head to receive the incendiary charge. The shells are picked up by the upper punch and raised above the die. Meanwhile the lower punch is depressed in the die to a preset depth, which is adjustable. The die cavity is then filled with loose incendiary powder, giving an accurately measured charge. In turn, each shell is then lowered over the die, which is equipped with a tapered sleeve to accommodate the stepped shape of the cavity in the shell. The loose powder is transferred upward through this sleeve into the shell and consolidated in place by the upward stroke of the lower punch. Pressure is applied to this lower punch by means of a floating roll equipped with an hydraulic release. The upper punch holding the shell is simultaneously pressed down by another floating roll.

The shell is then automatically ejected to a transfer plate which carries it across to the second loading head through a safety barricade which completely separates the two heads. In this second head, two charges of tetryl powder are successively loose-loaded into the shell and compacted by the same procedure as in the first head. The finished shells are carried away from the second head by a discharge plate passing over suction nozzles, which completely remove all traces of

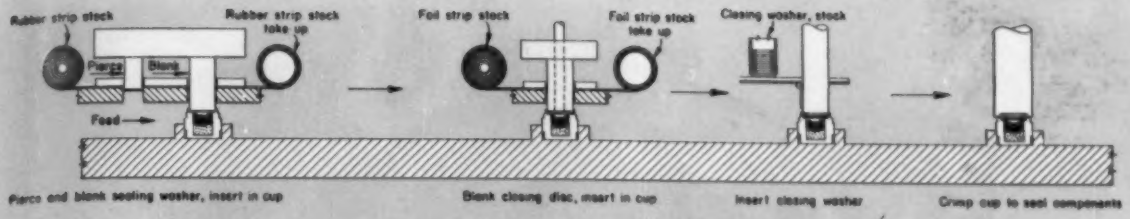


Fig. 4—Sequence of operations performed on one tracer element typifies techniques used in combining several operations in one machine. Machine automatically proportions out correct tracer and igniter charges and compacts the charges in the cavity of the container. In following operation, a rubber washer, copper disk and steel washer are inserted and crimped in place

loose powder from the threads. The shells are then ready for fusing.

By comparison, these shells were previously loaded by hand with pelleted charges, which were then consolidated in place by restriking. With the new twin-head loose loading machine, all operations are fully automatic. The only manual labor required is to keep the hoppers filled with powder and the conveyor belt supplied with shell bodies. The machine is fully protected with safety devices, such as one which prevents the spilling of powder when no shell is in place on the die to receive a charge. Production at the rate of 60 shells per minute has already been obtained easily; a much faster rate of output is thoroughly possible.

This same machine can be easily converted to load other sizes of shells by the change of a few parts, thus giving a versatility which ordnance contractors appreciate when considering investment in such highly specialized automatic equipment.

Another new design, for loading TNT charges into 60-mm mortar shells, replaces the earlier method in which the TNT, in the molten state, was poured into place and solidified as it cooled. This charge then had to be drilled to form a recess for the booster or detonating charge. The new Stokes equipment will allow flaked TNT to be used and will compact this charge and shape the desired recess in it automatically at the same operation.

▸ Indirect Advantages Obtained

More automatic operations and utilization of the principle of packing in place bring many desirable results, of which lower unit cost is just one. Compacting in place under accurately controlled pressure gives a charge with more uniform density of the explosive, with consequent greater consistancy in the rate of combustion and hence a higher degree of predictability of the ballistic performance of the projectile.

Other benefits not related to the performance of the finished product are also obtained. For instance, dangerous transportation of consolidated pellets of explosive from the pelleting bay to the loading bay is eliminated with loose loading. Safety over the entire production sequence is also increased. Elaborate mechanical and electrical controls enhance safety as well as contributing to greater uniformity. With less human labor and supervision, risks of accidents are further reduced. It is readily apparent that with handling and safety precautions made easier by automation, indirect costs are reduced, adding to the saving in the direct, purely functional, costs.

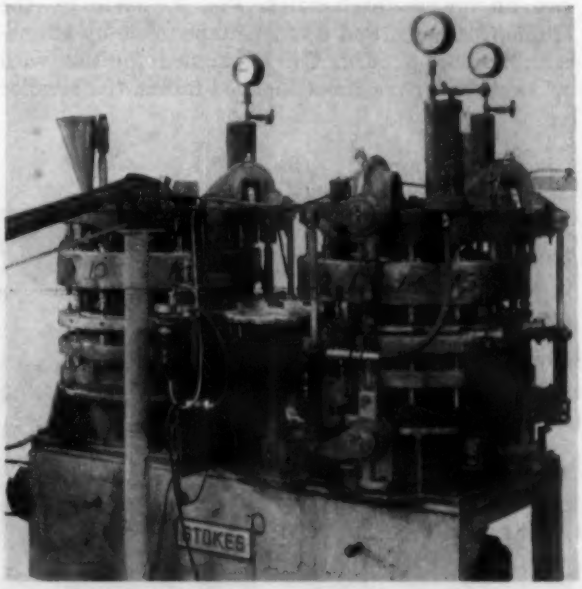


Fig. 5—Compacting-in-place principle is used in loading operation involving double-headed rotary press. Left head loads and consolidates incendiary charge. Right head then loads and consolidates two charges of tetryl into the projectile

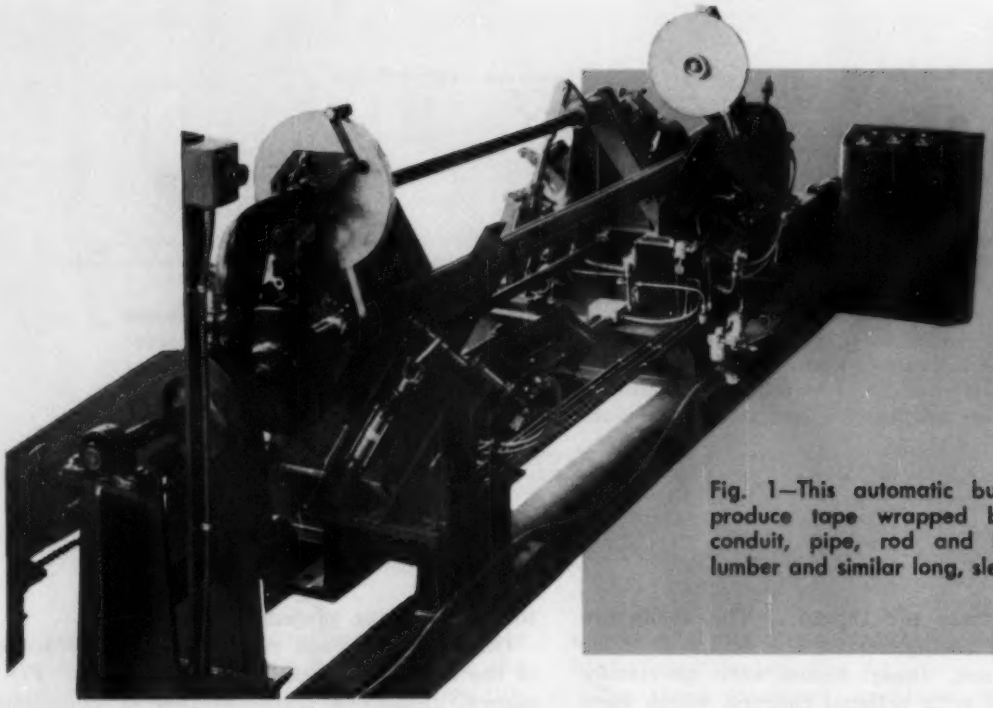


Fig. 1—This automatic bundler can produce tape wrapped bundles of conduit, pipe, rod and bar stock, lumber and similar long, slender items

LINE PRODUCES BUNDLED TUBING

BUNDLING CONDUIT AUTOMATICALLY rather than manually is helping the Spang-Chalfant Division of The National Supply Company of Pittsburgh realize savings of more than $3500 per year from bundling operations at its Etna, Pa., plant. Responsible for these savings are an automatic bundler, *Fig.* 1, made by the Guide Company, and filament tape made by Minnesota Mining & Mfg. Co. Designed for use with wide conveyor tracks or inclined tables, the bundler weighs about 6500 pounds, and occupies a space 17 feet wide by 5 feet long by 4 feet high. It accommodates 10-foot lengths of conduit and uses two 360-yard rolls of the "Scotch" brand filament tape.

Fig. 2—In this production-line installation an automatic bundler similar to that in *Fig.* 1 wraps three bundles of conduit per minute

At National Supply, as shown in *Fig.* 2, the 10-foot lengths of conduit roll down an inclined conveyor through labeling and final inspection stations to the bundler. The bundler operator allows the proper number of lengths to drop into the machine's V-shaped cradle and then presses a control button which starts the bundling cycle. The machine carries through the entire bundling cycle without further operator attention. Air-operated clamps guide the sections of conduit into their smallest perimeter within the cradle and hold them for taping. Next, the two tape-applying heads, one at each end, apply three wraps of tape under the right tension and with the proper amount of overlap near each end of the cradled tubing. The clamps then release automatically; two cut-off knives sever the tape; and the tightly-bound bundle is ejected onto a skid or pallet ready for shipment. The entire operation consumes only about 20 seconds.

Tape is used in a ¾-inch width to band the bundles of ½-inch, ¾-inch, and 1-inch conduit, and in a 1-inch width to secure the bundles of 1¼-inch, 1½-inch, and 2-inch conduit. Tape strength in excess of 180 pounds per inch of tape width, is derived from thousands of continuous rayon filaments imbedded in the adhesive to reinforce the tape.

Fig. 1—Bowl design to feed a double-diameter shouldered pin. A deflector is employed to turn the parts onto the slotted track where the small end may fall and the piece feed vertically from there on. In this application the slotted track is an insert assuming the position of a chord of the bowl diameter, permitting the parts that fail to orient to drop off either side and not wedge against the parts and outer wall. In instances such as this where the part's small diameter is less than one-third the large diameter the usual method of slotting the cast track cannot be employed. If it were, the land between the slot and the outer wall would be of sufficient width to permit the small end of the pin to ride past the slot without falling in

VIBRATORY FEEDING OF PARTS

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HANDLING THE PRODUCT is one of the major considerations in the engineering effort required to set up automated production facilities. Often, as much thinking must go into the problems of getting the parts into and out of the machines as is required to design the automatic controls that regulate the continuous cycles of the equipment. Bowl type vibratory feeders are commercially available as stock items wherein special shapes of bowl tracks and deflecting devices represent the tooling that adapts the basic unit to the specific application. This type of feeder is becoming increasingly popular in applications on machine tools. It is of special interest on assembly machines where a given operation requires the handling and feeding of several different parts.

To automate a manufacturing operation often requires equipment to feed parts to a production machine. Whether used to feed one automatic cycling machine or as reservoirs between machines in an automatic system, the bowl type vibratory feeder can often accomplish the triple roles of storage, orientation and movement of parts

Operating Principles

Vibratory feeders commercially available today have a base unit that houses an electromagnetic mechanism. On top of this base is mounted a bowl that holds the parts. As the magnet is energized by a pulsating current the bowl is pulled sharply out from under the parts. The parts drop onto an advanced position on the track in the bowl. The bowl is returned at a slower rate to its original position. Watching the action of parts in a vibratory feeder bowl under stroboscopic light clearly shows the parts in the air and falling again to the bowl. This explains why there is practically no wear on the bowl surfaces from the parts being fed. Parts do not scrape along the track as some people have supposed.

Both cast aluminum and fabricated sheet metal bowls are in general use. Fabricated bowls are generally more liable to be dented or bent in service. In sensitive cases this can adversely effect

feeding and orienting sufficiently to become troublesome or to completely shut down production. Cast bowls lend themselves best to accurately machined part tracks and to the delicate setting of orienting vanes, guides and deflectors. Often the cost of either of these types would be about the same for a particular application. Here the decision may be made primarily on the likelihood of superior performance. Where parts are extremely delicate, rubber or plastic coatings are applied to the inside of the bowl.

▶ Orientation of Parts

This type of feeder is primarily applied where the incoming parts are not oriented but are received in bulk containers and dumped into the feeder bowl. Each part assumes a random normal position of repose and starts on its journey around the bowl track. The quantity of parts in the bowl, within reasonable limits, makes little difference on the final feeding results. Where the parts are not symmetrical and it is required that they be discharged from the feeder each with the same side up and the same edge leading, the bowl track is outfitted with vanes, guides, slots, air streams or whatever devices can be made to direct the flow as desired.

This is a point where the ingenuity of the experienced application engineer is most apparent. Cylindrical pieces with shouldered outside diameters may proceed with their axis horizontal until they pass over a slot along the track which enables the small diameter to fall and the pieces be fed with the axis vertical. Parts with holes in only one end may pass over a partially interrupted section of bowl track whereon those that are upside down fall back into the bowl and the others continue on. Parts of certain configurations may be routed past a deflector vane which passes only those parts that are in proper orientation. Some odd shaped items have the mispositioned parts blown back into the bowl by an air stream so arranged as to blow across the properly oriented parts.

Delivery chutes or tracks can play an important role in the orientation of parts. Often these delivery tracks are made of stainless steel bar-stock shapes, averaging from 12 to 24 inches in length, and are bent into a modified *S* curve that enables gravity to feed the parts to the outlet of the track. There an escapement mechanism can take over the function of timed delivery as required by the machine being fed. The section of the track shape is designed to retain the parts in the same orientation that they are in as they leave the bowl.

In some cases where the shape and weight of a part cause it to feed in a position other than that required at the point of use, the easy way of correcting this tendency is to curve the track and twist it the 180 degrees, or whatever angle

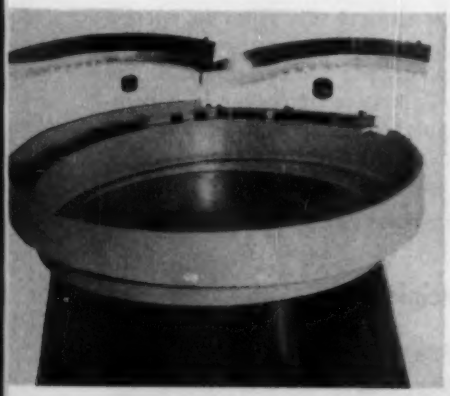

Fig. 2—Hex socket pipe plugs are fed past a deflector vane and onto a track length whose bottom surface is partially relieved in such a manner that the plugs whose holes are down have insufficient support and thus fall back into the bowl. Those that arrive with hole up, pass over this length and go on to the discharge chute. Different inserts handle different size plugs

Fig. 3—This part consists of two dome-shaped stampings welded together with a spacer between them. Natural feeding position of repose is inverted from the position desired. Development of hopper bowl is such that parts are inverted as they approach the point of final selection. From this point on, curved and slanted tracks, vane and air wipers are used to automatically reject parts that are not properly positioned

Fig. 4—Modified S-shaped delivery track is shown in place on a 6-inch diameter bowl. Normal practice is to provide an isolation gap between the feeder bowl and the delivery track so that the track does not hamper the vibrating action. Small feeders of this type are being used to replace parts bins on bench assembly work providing oriented accessibility of parts within a small work area

is required, to bring the parts out at the delivery location in the preferred position. The delivery track may also take the form of a chute. Here drop delivery is used to present the parts in a stack rather than in a horizontal line.

Many packaging operations use the feeder merely to establish the parts in single file so that they may be counted. In such applications, end for end orientation may not be required. A photoelectrically controlled gate in the delivery chute regulates the counted delivery.

A few examples of the numerous possibilities of orientation arrangements are shown in the accompanying illustrations. The authors are indebted to Mr. Floyd Smith, president of Perry Equipment and Engineering Co. through whose assistance the details of feeding problems are described and illustrated.

Feeding Rates

General feeding rate requirements of assembly applications run from 20 to 150 per minute. Some machining operations call for rates from 100 to 300 per minute. Packaging needs, where little or no work is to be done on the parts other than counting them, run from 100 to 600 per minute. Special applications using grouped feeder units with multiple tracks have been producing for regular service at better than 7500 per minute.

Amplitude of vibration is adjustable by a control knob. This enables the operator to select the feed rate best suited for the parts being fed. No greater amplitude of vibration should be used than is necessary to produce the desired feed rate, as orienting problems of jamming and overlap are likely to result.

Design shape and weight of the part have a great deal to do with the rate of practical feeding. In some cases difficulties in accomplishing uniform orienting are overcome by increasing the feed rate in order to offset the higher percentage of parts dropping back into the bowl, and yield a greater net at the delivery track. This ratio of oriented parts delivered to those dropped back into the bowl has practical limits if a desired feed rate is to be maintained. Excessive tumbling of parts within the bowl may have undesirable effects on delicate or polished surfaces.

Fragile parts can be successfully fed at moderate feed rates in the 30 to 100 per minute range by use of coated surface bowls. Depending on the configuration of the part, the bowl designer may be able to arrange multiple tracks in one bowl and thus increase output capacity. In cases where higher feed rates are required than the feeder manufacturer's tests have shown to be feasible, the practical solution is to use two feeders. At the other end of the scale where the rate of a given bowl is in excess of the requirements of the equipment it serves, one bowl track

Fig. 5—Bowl track is banked at certain zones to cause crowned parts that are wrong side up to fall off. Mass distribution and part shape is such that the part will feed uniformly only with the opposite side up from that desired at the machine. Use is made of further orientation in the track by inverting the parts 180 degrees as they move from bowl to point of use

Fig. 6—Designed to feed parts from horizontal plane to a stack, this bowl delivers to a flexible tube. Arrangement permits use of a bottom stack escapement slide to move parts away, one at a time, in timed sequence with a machine cycle. Application requires no end to end orientation of parts

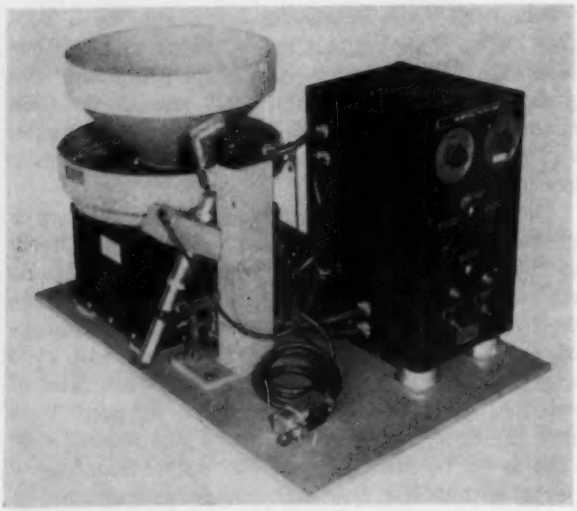

Fig. 7—Self-contained assembly of hopper, feeder, solenoid gate and counter and control unit engineered as a unitized attachment for a packaging machine. Controls provide for three predetermined feed rates. Hopper for reserve supply is mounted on a column (not visible in the picture) and does not vibrate with bowl. Flat head wood screws travel between adjustable steel rails to a detector head that signals when the last part required for the package has been fed. Electric brake stops all forward movement of parts

can be provided with multiple delivery tracks t service more than one point of use.

Bowl diameters usually range from 6 inches t 30 inches but neither limit need be adhered to t the situation warrants design to further extreme For operations requiring high feed rates the large diameter bowls are used. Where storage capacit in such bowls is inadequate, the bowls must b refilled too frequently. A parts hopper suspende above the bowl may serve any of several purposes (1) Increase the storage capacity, (2) limit th number of pieces in the bowl and thus improv orienting characteristics, (3) limit the time a fragile part is subjected to the vibrations of the bowl.

Design Considerations

Such a wide variety of parts are being successfully fed by this method that it certainly warrants careful consideration wherever problems of parts feeding are encountered. The product designer of today is increasingly on the lookout for design pointers to simplify the mass production of his product. To this end he joins the manufacturing engineer in wishing to learn the fundamentals of the feeder engineers specialty. It should be kept in mind that although there are other basic types of feeders known to the art, the popularity of the vibratory type is due largely to its efficiency and adaptability to handle such a great range of the parts feeding requirements of automation. Basic feeder units fitted out for various applications are examples of the trend to unitized construction of tooling attachments for automated production machinery.

Fig. 8—Fragile glass parts which will eventually become small radio tubes are fed flange end up. Sheet metal guide vane provides gradual orientation. Arrangement achieves a high feed rate by feeding parts in a highly massed condition, and by using air jets to advance them at a faster rate than the feeder would normally produce

Fig. 9—As the parts leave the bottom of the bowl they are feeding on an extra wide track that later divides into two separate track levels. Flexible delivery tracks go to a machine whose start and stop feed rate works against the constantly running bowl to build up excess pressure at the escapement mechanism. Pressure is relieved by use of a bent track bowl insert that allows parts to feed right back into the bowl when the line ahead is stopped

Fig. 10—Large nuts, two inches across hex flats, are fed by a 30-inch diameter bowl so that crowned surface is up. Replaceable steel insert tooling enables the bowl to handle a wide variety of parts. Setup shown provides multiple discharge for three lines to a machine tool

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Increasing volume of electronics production and possible emergency military demands bring serious consideration to "printed circuits" for automated electronics manufacturing. A new high volume method for die-blanking the circuits themselves is covered in this article

PRODUCING CIRCUITS

FOR MECHANIZED ELECTRONICS ASSEMBLY

GROWTH OF THE ELECTRONICS INDUSTRY during the past 25 years has been tremendous. Today, electronic equipment sales total approximately $5 billion per year of which slightly over half represents mass-produced home radio and television receivers. The balance of about $2¼ billion is largely composed of government contracts for relatively short runs of specialized equipment.

This extraordinarily high percentage of government participation is understandable when one realizes the extent to which our national defense depends upon electronics. Viewed as a curiosity during World War I, electronics assumed a role of major tactical and strategic importance during World War II. At present, about ⅓ of the cost of a search aircraft is in electronic gear. A modern heavy bomber has an estimated 350,000 individual resistors and capacitors soldered into associated equipment, while a battleship maintains tens of thousands of active vacuum tubes. Radar warning stations, guided missiles, and computers all add to the ever growing total. Ability to mass-produce to meet this demand is a basic design consideration for military electronic equipment.

The electronics industry can be divided roughly into two general groups: The product manufacturers such as General Electric, Westinghouse, RCA, Motorola, etc., who design, assemble, and market functional equipment; and the component manufacturers, such as Sprague, Aerovox, I.R.C., Allen Bradley, etc., who manufacture the resistors, capacitors, tube sockets, etc., from which all circuitry is derived. Because of the tremendous volume of individual components required, the electronic component manufacturer has developed a high degree of mechanization. Capital equipment for resistor and capacitor production facilities alone is valued in excess of $100 million. As an example, I.R.C. states their production capacity to be approximately one billion resistors annually—roughly four million per day. With efficient mechanized production, for instance they produce a ½ watt, 20 per cent tolerance, insulated resistor which passes MIL-R-11 "BF" Characteristic Specifications. It can withstand long shelf life conditions and is properly color banded and insulated. This resistor meets solder pot tests, and tests for security of terminals. Mass-produced, this component sells to the end equipment manufacturer in quantity for only about $12 per thousand pieces.

On the other hand, the radio and television manufacturing companies have purchased components and assembled and soldered these components into their equipment by hand for years. Hand assembly entails mechanically positioning the component in place on a chassis, cutting, forming and positioning lead wire to interconnect from component to component, and soldering these points of interconnection to insure a good electrical joint. However, by far the major cost of the end product is in the cost of the various components nec-

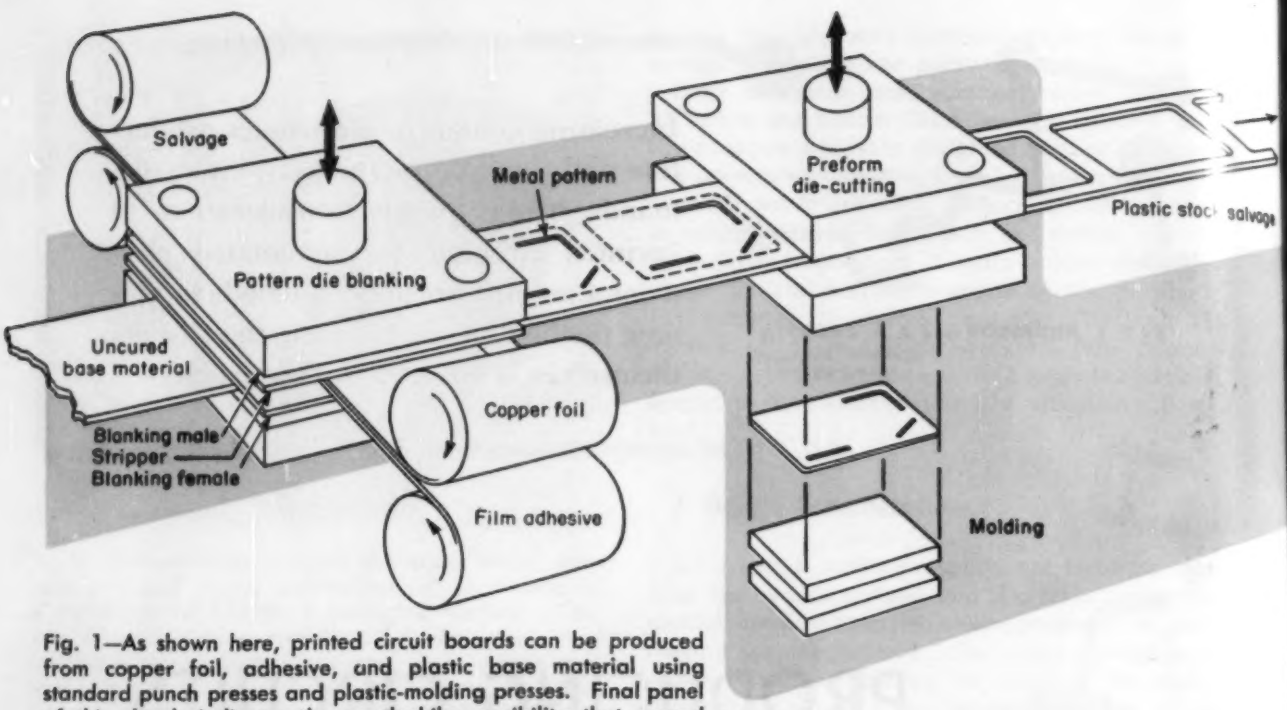


Fig. 1—As shown here, printed circuit boards can be produced from copper foil, adhesive, and plastic base material using standard punch presses and plastic-molding presses. Final panel of this sketch indicates the worthwhile possibility that curved and shaped circuit boards can be produced this way

essary for the circuitry. Radio and television manufacturers have estimated direct labor costs of hand assembly for high volume production of table radios at about 10 per cent of factory costs. Even for short runs of complex government equipment, direct labor costs rarely exceed 35 per cent. It has been with understandable slowness, therefore, that the electronic equipment manufacturers have approached the problem of mechanized assembly to replace hand assembly. Coupled with the relatively low direct labor savings possible, is the fact that mechanization of production has always tended to limit the degree of flexibility in product design. This is especially serious in electronics manufacture because of the frequency of circuitry changes. An old quip in the industry refers to a "girl with a soldering iron as the most adaptable machine possible of design".

▶ 1948 Outlook

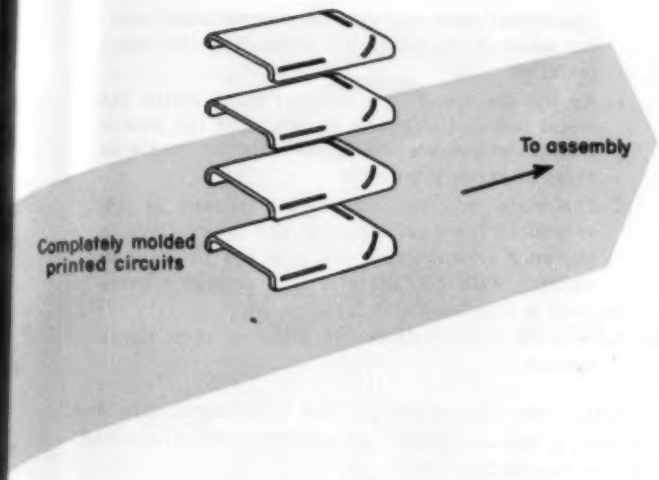
This, then, was the situation facing our national industrial mobilization people as late as 1948. In the unfortunate event of another war, military needs could skyrocket overnight to $50 billion yearly or more. While the components manufacturers, with a high degree of mechanization, could be expected to expand to meet these enormous requirements, the end equipment manufacturers would have to hire and train people to hand assemble complex electronic gear. For a major defense effort, some estimates placed the necessary work force at one million people. This, in itself, was serious enough, but when one considers in addition the time necessary to tool, to hire and train these people, and to produce by hand methods (perhaps six months lag time), then the critical nature of the situation becomes obvious.

Something had to be done to break the bottleneck caused by hand assembly. Analysis of the problem in 1948 established these broad principles:

1. New mechanized production assembly methods must be established.
2. Utilize existing component forms in order not to obsolete the available highly mechanized production equipment of the electronic component manufacturers.
3. Eliminate the need for a huge labor force or the need for particular skills which might require a relatively long period of training.
4. Use existing equipment less vital to a war effort.
5. Utilize materials and tools readily available in times of military emergency.

And so methods of mechanized assembly using printed circuits were born. The printed circuit is an old concept; practical forms were evolved and patented in the twenties; however printed circuits did not find a ready market due to availability of labor and the curiosity status of electronics. Based upon studies in Europe during World War II, and in this country in the production of the proximity fuze, the printed circuit was believed to be the most practical approach to automatic electronic equipment manufacturing.

A printed circuit is an electrically conductive pattern adhered to or supported by an insulating base. The production of printed circuit boards involves two main work divisions; the delineation of the conducting pattern on the insulating base,



and the fabrication of this supporting form into a shape and size suitable for mechanized assembly. The method thought most feasible involved the use of a laminated sheet plastic material to which had been bonded a thin sheet of copper foil. By means of a printing press operation, an acid resistant ink pattern could be applied to the surface of the copper foil and the unwanted copper removed by chemical action in a bath of etchant. The plastic board could then be punched (pierced and blanked) to provide holes into which component leads could be inserted for soldering to the printed pattern.

This idea appeared to be the answer to the bottleneck caused by hand assembly. The printed pattern eliminated the need for cutting, forming, and positioning interconnecting lead wires. The elimination of lead wires relieves the need for strategic diamond and sapphire wire-drawing dies. Since the board is flat, all solder joints are coplanar so that the board with components in place could be dip-soldered (that is, floated in a bath of molten solder), thereby effecting hundreds of connections in a few seconds. Existing components could be used by trimming and forming the leads for mechanized insertion into the holes pierced in the plastic base by a die. And also important, the graphic arts industry, part of the "butter" half of a "guns and butter" society and relatively less vital to a war effort, has existing highly mechanized printing presses and could be harnessed to produce printed circuits by the millions. Theoretically, given a photographic negative of the desired pattern and the foil-clad stock, any small printing shop (and there are thousands of them) could, within a few days, supply the printed sheets for etching and punching.

▸ Survey of Attainments

What has happened to this dream of automatic electronic production during the past eight years? On the plus side of the ledger, there are in operation mechanized assembly machines (commercially available at about $100,000) which will mechanically insert components into printed cards. Home radio and television receivers are on the market which have incorporated from one to five printed circuit sub-chassis. The productive capacity of existing plant space has been increased, without increasing direct labor. The component manufacturers have, in many instances, made available components more suitable for mechanized assembly and dip-soldering (solder coated tabs, efficient packaging for automation) without changing their capital investment in existing equipment.

On the minus side of the ledger, we see the dream is still far from reality. Eight years of frustrating production experience have clarified the difficulties of harnessing graphic arts techniques to the automatic production of electronic circuits.

Every graphic arts printed circuit procedure, by definition, involves the "printing" of a resist pattern, whether this "printing" is accomplished by a printing press, by photographic process, or by a silk screen. For subsequent etching or plating operations, this resist coating must be resistant to chemical attack, it must adhere well to a metallic surface, it must be nonporous, it must apply smoothly and evenly, it should air-dry rapidly, it must be capable of fine definition, i.e., hold sharp line edges, it must be easy to remove after chemical immersion, and both the resist and the solvent must be safe and economical to use. Unfortunately, there is no commercially available resist which combines all of these desirable characteristics. A hairline crack or a faint smear is cause for a reject after etching or plating, and insufficient removal of the resist will cause soldering difficulties.

This "printing" portion of the graphic arts processes is the cause of perhaps as high as 95 per cent of the manufacturing rejects, which average 3 to 10 per cent industry wide. The lack of a suitable resist, difficulties in printing onto a copper surface, variations in stock thickness, warp of the foil-clad laminate, all contribute measurably to the present status of photo-etching printed circuit manufacture.

▸ Printed Circuit Development

In an effort to avoid the difficulties inherent in pattern delineation through graphic arts processes, Automation Associates, under the auspices of a large material manufacturer, has developed a method of pattern forming by mechanical blanking. In order to utilize existing equipment and still maintain a high order of mechanization, the punch press was utilized as a "printer"—there are even more punch presses available than printing presses. Using a sheet of moldable material, the operations entail die-blanking a pattern from metal foil, adhering the blanked pattern to the sheet material, blanking the resultant circuit board into a size to fit shallow flash molds, and molding this preform with pattern in place to

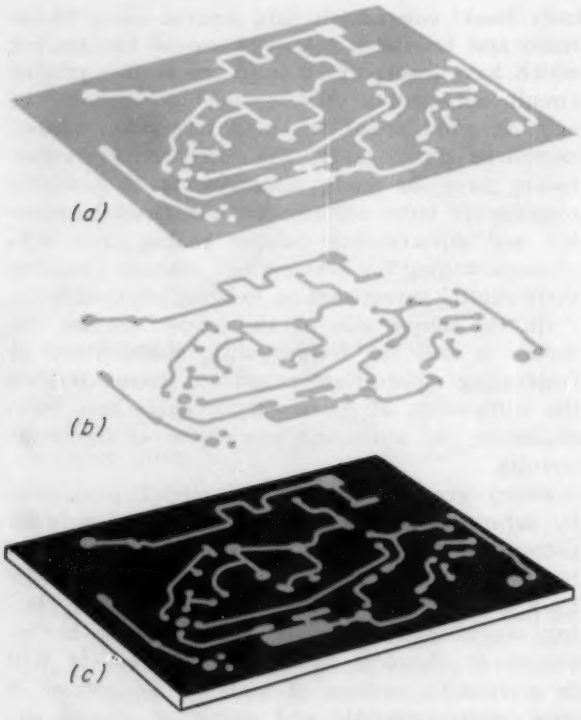


Fig. 2—These views show materials from various stages of a flat board production process similar to that sketched in *Fig.* 1 for shaped circuit boards, as follows: (a) Copper foil after wiring pattern has been punched out, (b) copper wiring pattern before imbedding in plastic, (c) cured plastic board with copper pattern molded in place

complete the desired printed circuit. *Fig.* 1 is a schematic diagram of this process, and *Fig.* 2 shows material in some of the stages of preparation.

Rolled copper foil in combination with a sheet of heat-sensitive adhesive film can be applied to the board. The foil should be in a continuous strip, several hundred feet long, wound onto a roll. The width of the foil need be only sufficient to contain the necessary pattern area. The adhesive film should be of the same width and length as the foil. Metal foils may be overplated with silver, solder, etc., as desired, prior to blanking. Moldable sheet material is slit into strips along the length of the sheet. The proper width of the material is the width of the finished piece plus a web allowance on both sides.

Briefly, the steps in the process are as follows:

1. A die-blanking tool is set up in a punch press. Strips of a moldable board material are fed beneath the female die plate of the tool.
2. Metal foil and adhesive film are fed from rolls through the tool between the stripper plate and the die plate, across the direction of board material flow.
3. Punch portion of the tool is heated. As the punch blanks the metal foil and adhesive pattern through the die plate onto the board material below, the heat causes the pattern to be superficially bonded to the board material. This superficial bond can also be accomplished without heating the punch by preheating the board material.
4. As the die opens, the stripper plate strips the metal foil and adhesive skeleton off the punch. The skeletons are wound on rolls for resale as scrap or reuse if possible.
5. The strip bearing the circuit pattern is advanced to the next stage in the press. Here, a blanking or steel rule die cuts the preform in registry with the pattern. The complete press cycle is 3 to 5 seconds.
6. Preform with pattern in place is then finish molded.

Only two pieces of capital equipment are required, a ten-ton punch press, and a 300-ton molding or laminating press.

Perhaps the outstanding advantage of die-blanking, in pattern forming, is the positive action of a blanking tool versus the inconsistencies of a printed pattern. As long as the tool is sharp (and tool life may be measured in hundreds of thousands of pieces) then the pattern will be properly delineated. Use of a moldable sheet material thus allows form in three dimensions, and makes possible tapered holes for mechanized assembly systems. A much more economical, reliable, and useful printed circuit form is achieved.

The mechanical blanking process was not designed to replace all etched or plated patterns as they presently exist. Facilities have also been designed and installed for the mechanized production of printed circuits by silk-screen and photoimage methods. However, factors of plant equipment and initial capital required are not as favorable as for the die-blanking technique. The volume of boards required, desirability of through-hole plating, tolerances, complexity of pattern, all will determine the best method of manufacture. But practically all printed circuit patterns for use as printed wiring can be designed to utilize this blanking process with its high degree of economy and mechanization. Generally, any volume of boards which justifies the cost of a punching tool for the fabrication of the board can be more economically manufactured by die-blanking the pattern.

Also important, using the technique we have outlined, ample production capacity through machine shops and custom molders is available now to satisfy industrial and possible emergency military procurement requirements. As a matter of fact, manufacture of printed circuits by this process parallels the manufacture of phonograph records. If it is desired, record producing facilities can be readily converted to the production of die-blanked circuits using their same basic equipment.

Mechanization is of paramount importance to the electronics industry both in peace and in war. It appears essential that the electronic equipment manufacturers review the present methods of printed circuit manufacture and adopt techniques which allow the utilization of existing manpower and equipment for the most efficient and economical production of printed circuits.

AIRCRAFT EXPERIENCE PROMOTES

BETTER STATIC SEALING

PERFORMANCE, reliability, safety and costs are guiding considerations in the design of a fluid power or control system. One small component part of such systems can vitally affect all four considerations—either adversely or favorably depending on the proper specifications. This critical component is the static seal.

Increased reliability requirements for automation applications have resulted in increased interest not only in materials used in sealing but also in the form of sealing used. This expanded interest is not confined to original equipment designers alone; in manufacturing plants, up-grading of existing equipment at overhaul to take advantage of the latest technological advancements is common and the problems to be solved parallel those confronting an original equipment designer.

Sealing problems are obviously not confined to one particular industry and the person in search of successful techniques used in other industries has a wide range to choose from. Eventually, however, it is realized that nowhere is sealing any more critical nor has as much research been accomplished as in the aircraft industry. Factors such as temperature, pressure, chemical properties, etc., affecting the sealing of fuels, lubricants and hydraulic fluids vary over an extreme range in aircraft applications and, since the early part of World War II, much progress has been made

Fig. 1—Examples of line of sealing devices manufactured by Franklin C. Wolfe Co. Design provides for metal to metal contact of faying surfaces; built-in groove is properly proportioned to allow for expansion of O-ring to form seal without exceeding elastic limit of the material

in developing suitable sealing materials to withstand the detrimental affects of these variables. Industrial users should have little difficulty in finding a material specification suitable to their specific operating requirements.

In aircraft applications the factors of performance, reliability and safety far outweigh the consideration of first cost and the form of sealing most used in these circumstances is the O-ring in groove type. Considerations for the design of automation equipment, in a general sense, approximate those in the aircraft industry and, as could be expected, more designs are incorporating the O-ring type of sealing where possible. This type of sealing is based upon the fact that rubber is not compressible and, though it resists deformation, it can be deformed. Controlling the deformation in a groove causes the O-ring to make line contact with confining surfaces to set up a barrier without subjecting the gland to unnecessary and damaging extrusion stresses between faying surfaces. Dimensions are critical in O-ring sealing. The dimensions which must be controlled are the O-ring cross section and diameter; and the depth, inside and outside diameters of the groove. Close tolerances on all five dimensions are required in the classical use of the O-ring since variation of any one can adversely affect proper sealing.

Of special interest to industrial users are developments in the aircraft industry, which have been aimed at obtaining O-ring quality seals without the attendant fitting problems. A family of sealing designs of the Franklin C. Wolfe Co. illustrate these developments, *Fig.* 1. Their approach to the problem has been that maximum sealing effectiveness can be obtained by arriving at a proper ratio of a sealing gland mass to groove void to give required deformation of the gland without exceeding its elastic limit. With the proper design and specification of material, the gland should be reusable since it is not stressed beyond the point where it will lose its original characteristics. The form of sealing provides for metal to metal contact of faying surfaces and it also provides t[he] necessary groove. Dimensions are not as much [a] critical individual problem for the user since, [in] effect, he is supplied with a packaged O-ring a[nd] groove.

As an example consider the fastener seal lin[e]. An individual unit consists of an O-ring and retainer ring. In a typical application involvin[g] the sealing of a bolt, the retainer ring encompasse[s] the O-ring and forms a ready made void of prope[r] dimension within which the O-ring expands as th[e] bolt is tightened; the O-ring is not subjected t[o] undesirable stresses as the bolt is torqued. Be[-] cause of the retainer ring, this type of seal ca[n] be applied to bolts and studs and with back-u[p] washers to tube fittings. Another example, th[e] orifice seal line, consists of a metal gasket with a built-in O-ring groove on both of the two flat surfaces. After fastening, the rubber seal expands within the grooves and forms a seal without excessive torque pressure being applied to the unit. A closure seal line offers the same type of unit for closing off ports, access doors, etc. The built-in groove feature offers a simple and practical solution to the shop faced with the problem of updating the sealing of equipment for the more reliable performance that automation requires; the advantages of not having to machine a groove to obtain superior sealing are evident. In applications where static gasket seals must be broken frequently for inspection and maintenance, upgrading the seal by using the built-in groove type could provide for considerable savings in cleaning and resealing time.

This discussion on sealing furnishes an excellent object lesson as to the benefits which experience in one industry offers to an entirely different industry. There are many general problems which are common to most industries; immediate practical results in a particular case can often be obtained by identifying the accepted solution in other industries where the general problem is prevalent.

AUTOMATIC PROGRAMMING

PREPARING a problem for solution by a computer is called programming and, for major commercial problems, can involve from three to ten weeks of preparation time and require the services of experts trained in the language of the computer. Effective use of computer time has been limited by the program requirements. Realizing this limitation, Remington Rand for the last six years has investigated automatic programming.

Bases for automatic programming are the inherent standard routines and subroutines in all computer programs and the memory ability of the computer. In effect the computer has been supplied an extensive library of standardized subroutines; automatic programming then revolves around determining the least amount of special effort on the part of the operator in having the computer automatically draw upon this stored information.

Two basic types of automatic programming for Remington Rand's Univac system are: Interpretive routines and compiling routines. An interpretive routine translates a master program into computer code and performs the required operations.

Compiling routine involves the automatic decoding of the master program, selection of standard subroutines from the computer's library and generation of other subroutines where necessary. The computer also allocates memory space, assembles all the subroutines into finished programs, and finally records the program on magnetic tape.

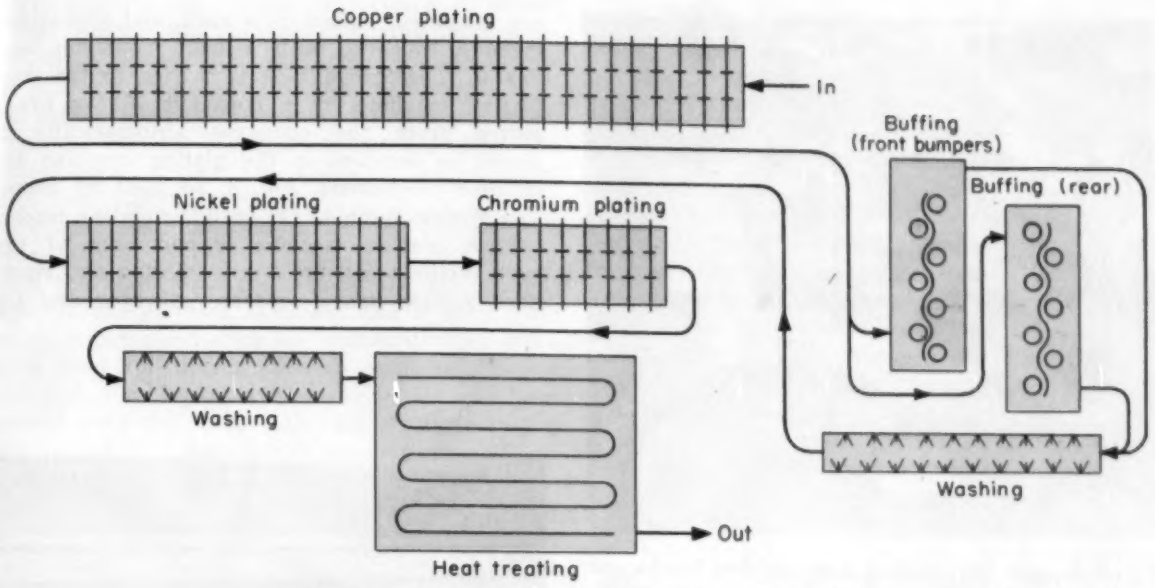


Fig. 1—Layout of automated cell type plating facility for automobile bumper bars. Further refinements in the copper plating operation are even expected to eliminate the automatic buffing and washing operations

CELL TYPE PLATING

AS A CONTINUOUS PRODUCTION METHOD

Modern handling techniques applied to a formerly manual method of plating brought this company a high production facility with the advantages of cell type plating

MANY PEOPLE THINK that the current rush toward increased automation is due solely to management decisions to reduce direct labor expenses. Such is not the case. Such factors as increased production volume, human limitations, tighter tolerances or specifications, as well as improvements in available know-how, machines and instruments, are often more important in management decisions to "go automatic".

Modern Cell Type Plating

A case in point is Oldsmobile's new bumper bar plating installation. Their volume has climbed over 90 per cent in the past two years. Sheer mass involved is an important consideration since they are loading racks that weigh close to 1000 pounds when full. Their plating specifications are more exacting as pointed out by J. F. Wolfram, Oldsmobile general manager, "Due to the greater use of road salts and other corrosive mixtures for melting ice and snow on the highways, today there is an increasing demand for high quality plating. Oldsmobile's plating quality on its current models is even better than pre-World War II."

Basic decision for the new line was the determination to plate racks of bumper bars in individual cells. In its former system, Oldsmobile racked its bumpers to hang vertically, and moved the racks continuously through a large plating bath. Wrap-around bumper bars require the use of anodes placed in conformance to the major planes of the bars to give even distribution of metal coating. In the continuously moving plater, anodes had to be placed on the top and bottom of the plating tank. This was far from an ideal arrangement since the anodes had to be bagged, and dirt and foreign material tended to settle on the bottom anodes. Individual cell type opera-

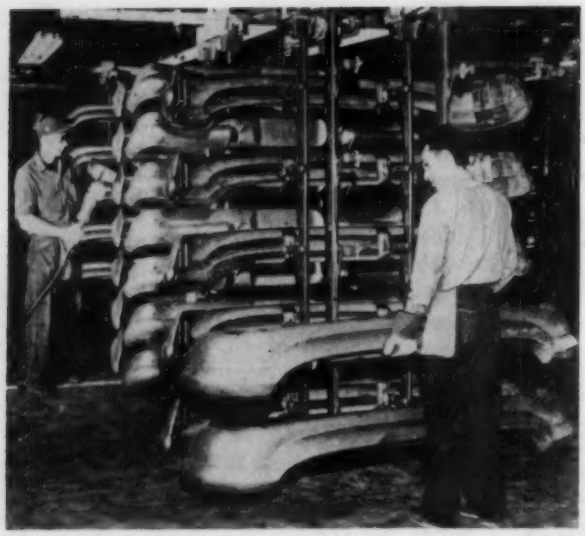


Fig. 2—Bumper bars formed from polished blanks are loaded on racks in the plating system and given touch-up polishing where needed

tions allow use of anodes hung near the sides of the tank which can easily be made to conform to the shape of bars racked to lie horizontally and at rest during plating. In such an arrangement the amount of dirt and foreign materials settling on the anodes can be kept to a minimum and anode material can be held in place simply.

Use of cell-type plating might have been considered a reversion to a slow manual operation. It is usually carried on by having an operator deposit work in a plating bath by hand or with an overhead hoist. After the plating time is up, he goes back to the bath, picks up the work and walks it to the next station.

But the Oldsmobile installation gains the advantages of cell type plating as well as being a high production automated facility. Plating units supplied by the Hanson-Van Winkle-Munning Co., augmented by an auxiliary conveyor system built by Jervis B. Webb Co. are basic components in this improved operation. Westinghouse Electric Corp. engineers have assisted the auto company in attaining good leveling of the copper plating with their Wes-X PR process. Their work is continuing, and it is believed that the copper finishes will eventually prove smooth and bright enough to make present buffing operations unnecessary. *Fig.* 1 shows the layout of the new facility and the present location of the automatic buffing operations.

▶ Bumper Bar Facilities

In this plant, flat steel blanks for the bars are automatically polished, then the bumper bars are formed and brackets welded on them. Pieces are inspected, loaded on a rack, and subsequently given a touch-up with a hand polishing wheel, *Fig.* 2. The loaded rack is carried to the copper plating machine by a conveyor. Racks are removed from the conveyor automatically and placed on carriers in the plating machine by a transfer mechanism, *Fig.* 3, supplied by Hanson-Van Winkle-Munning Co. with the plating machine.

Each plating machine is composed of three main sections—pre-treatment, plating and rinsing. Each section has a separate conveyor and separate hydraulically operated elevator mechanisms. Racks of bars over the pre-treatment tanks are elevated, advanced and lowered simultaneously, except for certain special stations. Racks are individually and selectively handled in the plating section. In the rinsing section the racks are handled as in the pre-treatment section. Transfer between sections within the plating machine is also automatic.

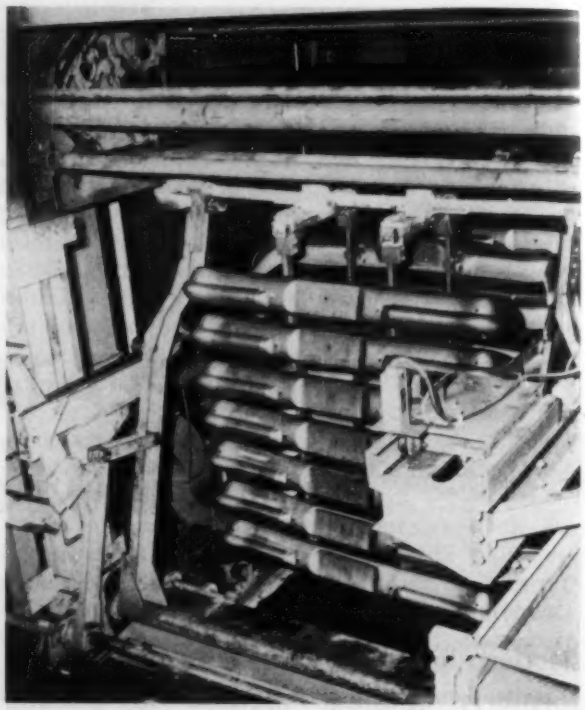


Fig. 3—A rack of bars is shown just as it is being automatically transferred from the supply conveyor to the copper plating machine. Transfers between sections of the plating machine and back onto the auxiliary conveyor system are also automatic

Carriers have rollers on their ends. These rollers ride on continuous tracks on the elevators. Chains propel the carriers along the tracks from station to station. One of these chains can be seen at the upper left in *Fig.* 3. A pair of chain loops is

responsible for the horizontal forward movement in each section, and each set of chains has a separate drive motor and speed reducer. The chains are guided by suitable rails, and are equipped with side attachments that resemble inverted oar locks. When the carriers are in an elevated position the attachments engage the carriers and advance them from station to station.

Elevator assemblies on which the carriers roll are supported by carrier guides that ride up and down the framework columns of the plating machine as the elevator is raised and lowered. The design is patterned after the standard roller skate guide used for lifting carriers on a return-type conveyor. *Fig.* 4 shows a carrier which has been lowered over the first bath and is supporting a rack loaded with bars which are immersed.

Pre-treatment cycle for the copper plating machine is—alkali wash, cathodic cleaning, cold rinse, hot rinse, acid etch, cold rinse, another cold rinse, anodic cleaning, cold rinse, acid dip, cold rinse, cathodic cyanide dip, cyanide copper strike, and a reclaim rinse. The acid etch station and a rinse station in this cycle are two special stations

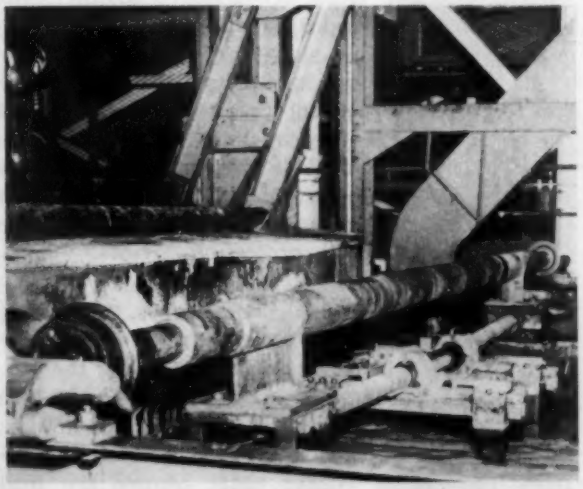


Fig. 4—Bumpers immersed in this pre-treatment bath are held by a rack which in turn is supported by the plating carrier. The carrier is raised and lowered by an elevator. When raised, the carrier is rolled along tracks on the elevator by a pair of chains with engaging attachments

where carriers are picked up before the rest of the racks in the section. Advanced pick-up is performed by a separately-actuated hydraulic mechanism which is controlled by an adjustable timer. Pre-treatment baths for the copper plating line are shown in *Fig.* 5 with the elevator down. The copper plating line processes 22 racks of bars per hour.

▸ Plating Bumpers

Bars are then plated with 0.0015-inch of copper in the individual cell-type copper plating baths. *Fig.* 6 shows a cell with a rack of bars being plated. The anodes around the sides of the cell conform to the outline of two wrap-around bumper bars facing away from each other.

A selective cell type plating system is used so that a rack of bars to be plated is lowered into an empty cell, by-passing other cells. Racks of plated bars are picked up from a cell after a predetermined time, and by-pass other cells as they are delivered to the after-treatment tanks. Copper plating requires about one hour, after which the rack of bars is given a reclaim rinse bath, a final hot rinse, and then automatically transferred from the plating carrier to a conveyor carrier, *Fig.* 7.

These conveyor carriers take the racks of copper plated bars to the automatic buffing lines. There are two buffing lines—one for front bumpers and one for rear bumpers. The racks are automatically carried to the proper buffing line as directed by the adjustment of a selector switch on the conveyor carrier. After being buffed the bumper bars are washed and taken to the nickel plating machine. This machine also plates 22 racks of bars per hour.

Nickel plating equipment is similar to the copper plating machine. Racks of bumper bars are automatically transferred to the plating carriers; bars are cathodically cleaned, cold rinsed twice in separate tanks, dipped in a cathodic cyanide bath, given a flash coating in a cyanide copper tank, cold rinsed, then nickel plated. Nickel plate

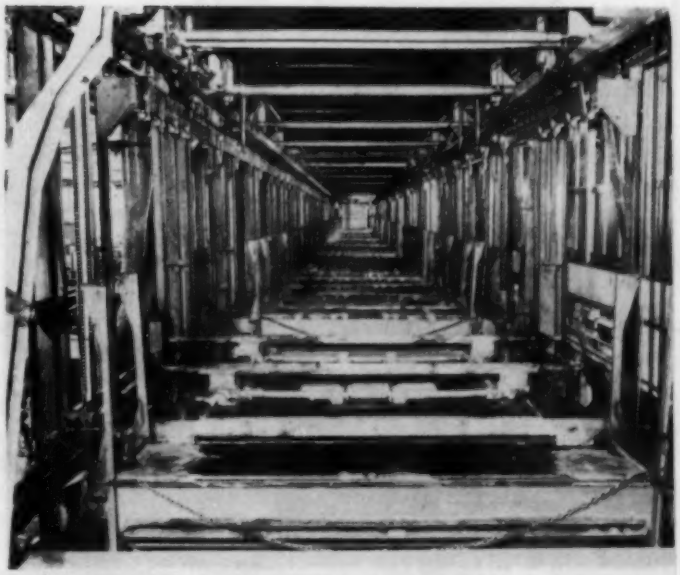


Fig. 5—This view shows the copper plating machine with racks of bars immersed and elevator mechanisms at ends of tanks

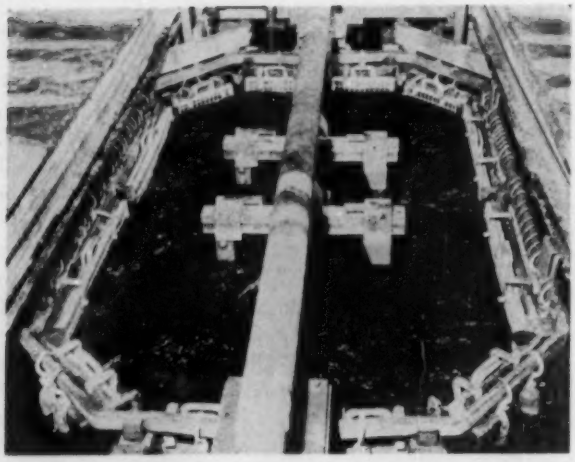
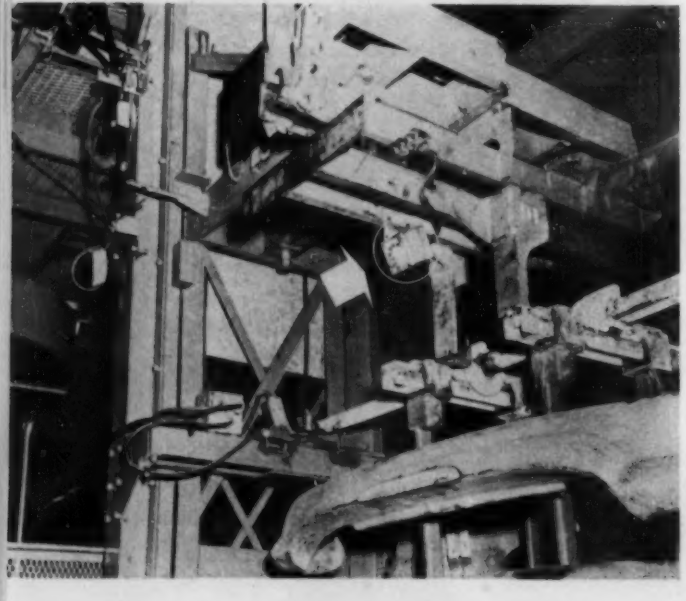


Fig. 6—A major advantage of this cell type system is the feasibility of placing anode material to conform to the shape of the wrap-around bumpers. As can be seen the anodes hung around the sides of the cell outline the shape of two bumpers facing opposite directions

0.0008-inch thick is deposited on the bars in individual cells with conforming anodes. This operation takes 24½ minutes. A reclaim rinse, a cold rinse and a hot rinse follow the nickel plating.

Bars are reracked for chrome plating. Racks of bars are then automatically loaded on the carriers in the chrome plating operation which is similar to the copper and nickel plating machines. Thirty racks of bumper bars per hour are cathodically cleaned, cold rinsed, dipped in a cathodic acid bath, cold rinsed and then warm rinsed.

Fig. 7—Here a rack of copper plated bars is being automatically transferred to one of the conveyor carriers (marked 91). Note the selector switch which is set to automatically route the carrier



Lowering of a rack into the cathodic acid ba[th] is delayed with respect to the cycle of the elevat[or] for the chrome pre-treatment section. This delay [in] set-down is accomplished by separate hydraul[ic] means similar to that used for advanced pick-u[p] in the copper plating unit. After chrome platin[g] which requires 2½ minutes, the bars pass throug[h] two reclaim rinses, a cold rinse and a hot rins[e].

Racks of chrome plated bars are automaticall[y] unloaded from the plating carriers. The bars ar[e] reracked and sent through a 550-degree stres[s] relief oven. A trip takes 30 minutes. This ove[n] treatment is included to prevent hydrogen em[-] brittlement which would cause future cracking.

▶ Conveyor Notes

Conveying between plating machines is handled by a power-and-free system some 5000 feet in length and takes place on four separate levels connected by ramps and automatic elevators. The carriers moving the racks of bumper bars are individually directed so that they automatically travel to designated stations. Their progress is controlled by about 3000 limit switches which are used in the system. The automatic control features include transfer from one loop to another, bypassing of overcrowded areas, and floating on a moving chain when a slow-up occurs.

There are four types of lifts used—the 2-position type, the 3-position type, the offset type and the rotating type. Twenty-nine lifts are incorporated in the system. The lifts include such features as 2-speed operation, carrier stabilizers, automatic transfer mechanisms on and off lift sections, and limit switch protection devices.

The system includes 11 spring pusher type conveyors and six solid pusher conveyors. The spring pusher conveyors were designed to store the conveying carriers in banks without stopping the conveyor. The pushers are spaced on 10-foot 8-inch centers and move at a speed of 6 feet per minute. Besides starting the heavy static load of the carriers, the spring pusher must convey the load without losing it. Spring pressure against the pusher bar to meet these requirements is about 250 to 300 pounds. Consequently, both the driven dogs on the carrier and the pusher bar on the spring assemblies are made of heat treated alloy steel.

A further quality asset in this cell type plating installation is that each plating cell has its own motor-generator set and each plating bath its own electrolytic purification system with individual filtering and heat-exchange system. Racks coming out of each bath are identified, and if poor bars show up the responsible bath can be immediately pin-pointed.

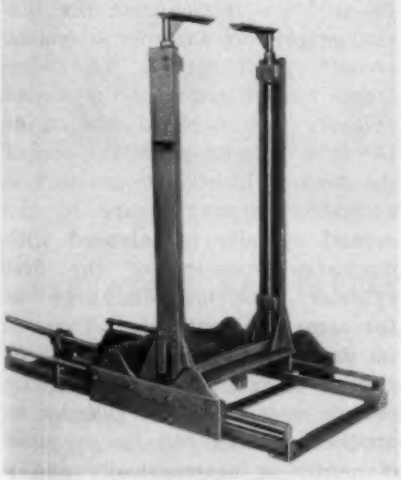
This system is a good example of the application of automation techniques to an old manual method to obtain the advantages of that method as well as automatic high volume production.

AUTOMATION new equipment

Machines and plant equipment designed for more automation operations

AUTOMATIC LOADER

Parts transfer mechanism can be adapted to any automatic metal finishing mechanism operating with an intermittent motion. Originally designed for automatic electroplating machinery, automatic loader is also used in automatic parts finishing operations such as anodizing, phosphate coating, etching, electropolishing, oxide coating, painting and cleaning. Loader will accommodate a monorail conveyor system which operates on different planes. Entire transfer mechanism is mounted on a reciprocating carriage, moving on rollers in a channel track. Cam followers attached to lifting arms duplicate eccentric contour of side plates to raise and lower lifting arms into loading and unloading positions. Cycle of unit is controlled by limit switches of the automatic processing machinery, actuated by a hydraulic cylinder, or an electric drive, to move in unison with transfer cycle of the automatic. Processed parts are unloaded from automatic onto monorail conveyor as unprocessed parts are loaded from monorail onto automatic. **Wagner Bros. Inc.**, 467 Midland Ave., Detroit 3, Mich.

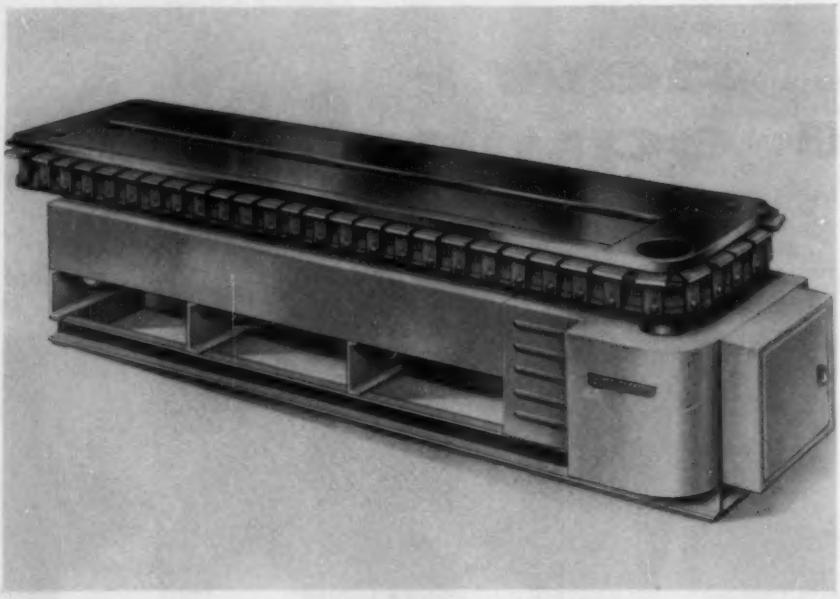


Circle No. **1** *on Reply Card*

CONTROL OF VERTICAL SPINDLE MACHINE TOOLS

Called the Micro-Positioner, new device provides completely automatic method of accurately locating production parts under all types of vertical spindle machine tools. Micro-Positioner table is controlled by means of a steel tape indented by an automatic marking device from information on blueprints or by locating the vertical spindle machine tool over a previously marked part. Once the tape has been indented, all subsequent production can be run by means of pushbutton controls on a master console which is part of the unit. Jigs and fixtures on limited production quantities are eliminated by use of Micro-Positioner. Tolerances within 0.0003-inch can be held when required. **Topp Industries Inc.**, 5255 W. 102nd St., Los Angeles, Calif.

Circle No. **2** *on Reply Card*



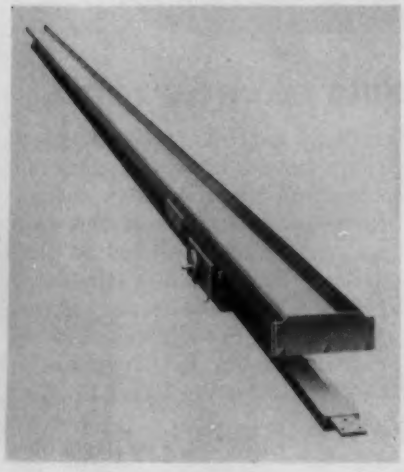
STRAIGHT LINE INDEXING CHASSIS

Designed for application to both automatic and semiautomatic assembly operations, new straight-line type indexing chassis has accessible faces for mounting various types of operational devices for drilling, tapping and staking. Area is also available for mounting hopper feeders in any position around the chassis. Unit is available with 48 to 72 carriers, 3, 6, 9, or 12-inch index travel, and with either vertical or horizontal mounting surfaces on the carriers. Work carriers attached to a double roller chain have ball bearings mounted in both horizontal and vertical planes, guided in tracks mounted on the chassis frame. Smooth index is provided by cam indexing unit which drives a sprocket incorporating a pin clutch for easy alignment of operational devices and tooling. Warner electric clutch brake, with standard electric motor drive, provides complete flexibility in operational cycle control. Units provide a standard, basic chassis for a variety of automation applications. **Swanson Tool & Machine Products,** Erie Pa.

Circle No. 3 on Reply Card

VIBRATING CONVEYOR

Built in 12-ft sections, vibrating conveyors are available in deck widths of 5, 8, 12, and 24 inches. Sections may be cut to obtain any odd length. Height from floor is 14 inches maximum. Lightweight mechanical conveyor will move materials of good conveyability up to 45 tons per hour. Feature of unit is a totally enclosed, oil immersed drive, which prevents entry of foreign matter into drive mechanism. With eccentric and bearings partially immersed in oil, unit is continually splash lubricated with a high grade oil. Illustrated unit has 12-inch wide and 48-ft long stainless steel deck consisting of one power section and three extension sections. **Jeffrey Mfg. Co.,** Columbus, O.



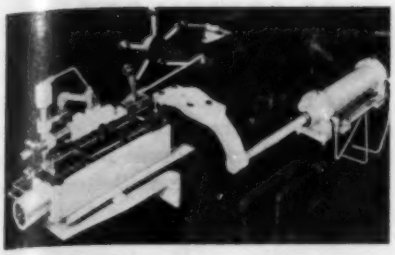
Circle No. 4 on Reply Card

CONSTANT FLOW PUMP

Designed for research laboratories, process and manufacturing plants, new flow pump maintains a constant rate of flow regardless of discharge pressure and is capable of operating under pressures up to 10,000 psi. Air pressure operates high pressure discharge valves and hydraulic driving pump which operates two

double-acting hydraulic cylinders. Action of these two cylinders is controlled by servovalves. While the first cylinder is delivering at a constant rate the second cylinder is being filled. Filling process takes place faster than the discharge rate to assure continuous, smooth pump action. An electronic release activates the second cylinder into forward motion as the first cylinder nears the end of its stroke. Electronic interlock is activated when pressure of the second cylinder is balanced with discharge pressure of the first cylinder, assuring discharge at the same constant rate. There is no drop in discharge pressure or change in rate of delivery during change over from one cylinder to another. Pump can be operated manually or automatically and a special gear box allows selection of 40 different flow rates ranging from 10 to 600 cu cm per hour. **Exline Engineering Co.,** 1636 E. Sixth St., Tulsa, Okla.

Circle No. 5 on Reply Card



HYDRAULIC TURRET DRIVE

Designed as a new method of modernizing hand turret lathes, hydraulic turret drive is easily adapted to standard ram type turret lathes No. 1, 2, 3, 4, and 5. Drive eliminates hand indexing and traversing, reduces number of rejects and tool breakage, increases tool life and assures improved finishes. In operation, cycle is started with a hand control valve. Master valve then controls required operations in a preselected sequence, leaving operator free to inspect and to prepare next piece for chucking. **A. W. Cash Co.**, P. O. Box 551, Decatur, Ill.

Circle No. **6** *on Reply Card*

ELEVATING BAR FEEDER

Designed to handle short bars and studs up to 6 inches long, feeder takes parts from magazine, elevates them to desired height and presents them for feeding to next production machine, thus making machine fully automatic. Delivery rate can be varied from 1 to 12 pieces per minute. Feeder can be modified to suit individual needs. **Feedall Inc.**, Willoughby, O.

Circle No. **7** *on Reply Card*

WIDE BAND POCKETSCOPE

by Waterman

Size: 12" x 6" x 7"
14 Pounds

MODEL S-14-B

DC COUPLED
REPETITIVE OR TRIGGER
1.8 μs RISE

6 INCHES

ANOTHER EXAMPLE OF Waterman PIONEERING...

The WIDE BAND POCKETSCOPE, model S-14-B, hits a new high in frequency response for light, compact, truly portable oscilloscopes. The response extends all the way from DC to 700 KC within —2 db without peaking. Thus providing a pulse rise time of 1.8 microseconds. Furthermore, sensitivity has not been unduly compromised in order to accomplish such fidelity. The vertical sensitivity is 50 millivolts rms/inch. The sweep is operated in either a repetitive or trigger mode and covers a range from 0.5 cycles to 50 KC with synchronization polarity optional. Other essential vertical and horizontal amplifier characteristics include non-frequency discriminating attenuators and gain controls as well as individual calibration voltages. Additional provisions for direct access to all the deflection plates, the second anode, and the amplifier outputs help to make the S-14-B a standout instrument of flexibility and utility. All this plus portability! The incredibly small size and light weight of the S-14-B now permits "on-the-spot" use of the oscilloscope in all industrial, medical, and electronic fields. Its rugged construction assures "laboratory performance" regardless of environment.

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S-14-B WIDE BAND POCKETSCOPE
S-15-A TWIN TUBE POCKETSCOPE
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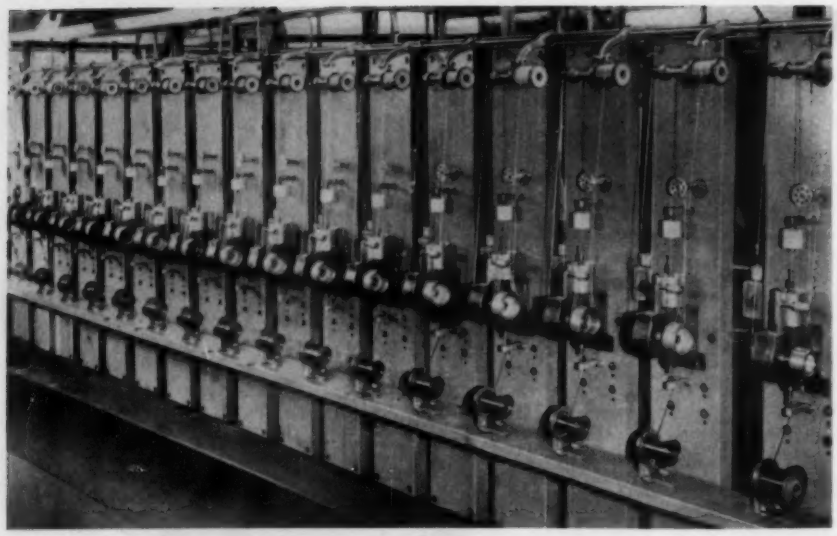


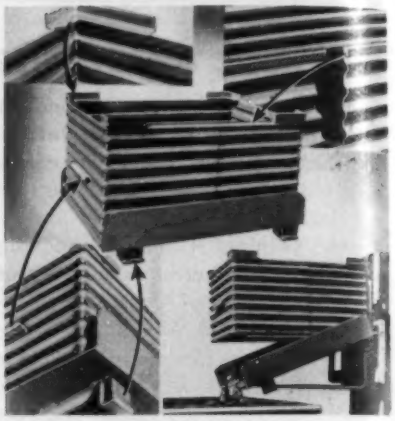
WIRE INSULATING EQUIPMENT

Designed for rapidly producing served wire from bare, varnished or enameled wire for radio coils, loop antennas and other electronic and electric applications, wire insulating equipment has two capstans. The large capstan handles 1600 feet per hour of 20 to 34 gage wire, or 12,800 feet per day. The small capstan handles 1200 feet per hour of wire from 35 to 40 gage. Equipment is available in single or multiple units. Motor equipment consists of a constant speed ⅓ hp, 220v, three-phase motor. A level wind device is included with the equipment. **Geo. Stevens Mfg. Co. Inc.,** Pulaski Rd. at Peterson, Chicago 30, Ill.

Circle No. 8 on Reply Card

DROP BOTTOM BOX

Made for use either with a positioning stand or for controlled dumping by fork truck, drop bottom boxes incorporate new safety features. Corrugated all-steel welded units have safety corners which prevent box shifting during stacking or when two or more are transported up or down grade by fork truck. Corrugated rolled-steel legs on the bottom of the box lifting plate are reinforced with steel



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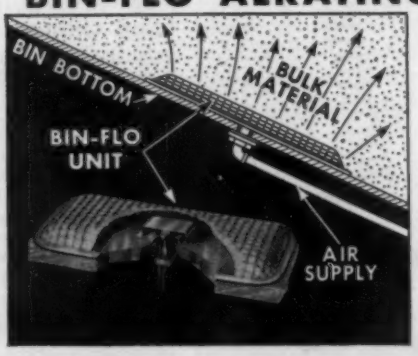
BIN-FLO AERATING UNIT

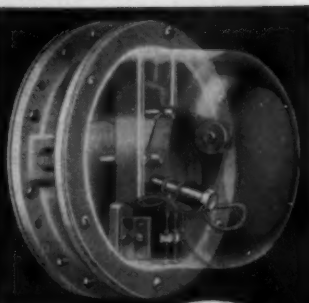


Provides Steady Flow of Dry, Finely Ground Materials which tend to bridge in storage. Uses only small amount low-pressure air.

BIN-DICATOR BIN LEVEL INDICATOR

For All Bulk Materials

signals change in level; automatically starts and stops filling and emptying equipment.



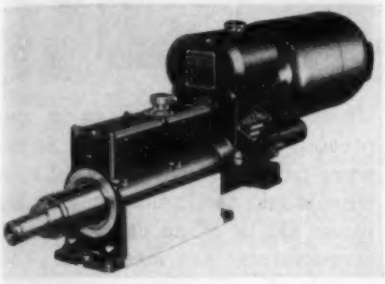
THE BIN-DICATOR CO.

13946-E2 Kercheval • Detroit 15, Mich.

NEW DETAIL DATA BOOK FREE

plate. Boxes also have lapped joints, replacing butt welds, for greater strength and safety. When used on a positioning stand, legs at bottom of box engage the stand and the drop bottom automatically opens to discharge materials into the stand tray. When used for automatic dumping by fork truck, a reinforced box hanger engages the mast of the fork truck for controlled materials discharge into a truck or conveyor. **Palmer-Shile Co.**, 16040 Fullerton, Detroit 27, Mich.

Circle No. **9** *on Reply Card*



TAPPING UNIT

Self-contained fully automatic lead screw tapping unit may be mounted in any position. It is furnished with a flanged quill and slotted spindles for close coupled multiple-spindle tapping heads. Guide bar brackets afford rigid support for guide bars and multiple head. Model is also available without quill flange and with a 1-inch bore adjustable adapter spindle for single-spindle tapping. Tapping unit is equipped with limit switches at each end of the quill travel to provide protection against overtravel of the spindle. Tap protection against end thrust is provided by construction feature which stops spindle instantly should the tap enter an undrilled hole. Stroke length is adjustable from 0 to 4 inches; a dial control can be locked to prevent tampering. Feature of tapping unit is short setup time required for changing lead screw, spindle speed and spindle travel. Standard lead screw pitches, from 6 to 32, are available. Unit is especially designed for single or multiple-spindle precision tapping of special machines. **Wisconsin Drill Head Co.**, Butler, Wis.

Circle No. **10** *on Reply Card*

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achieved for the assembly of this window handle.

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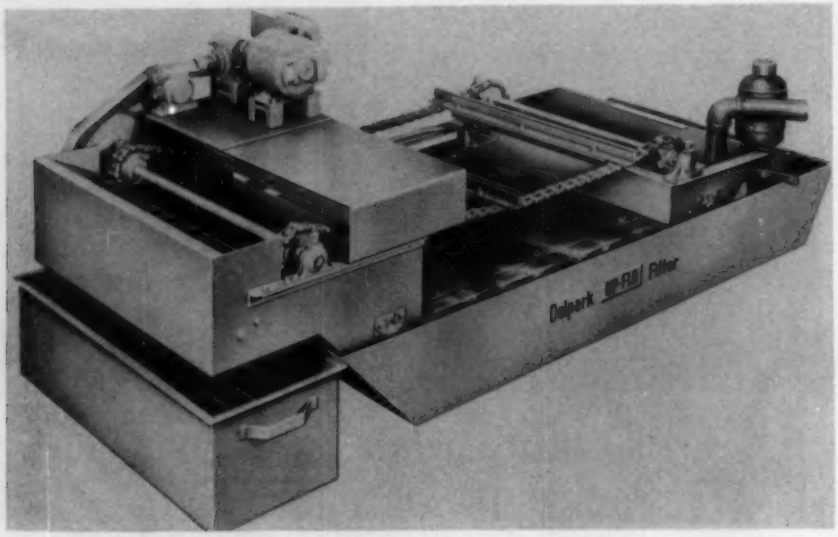


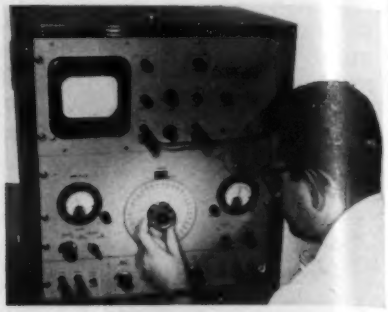
AUTOMATIC INDUSTRIAL FILTRATION

Permanent filter medium is used in an automatic industrial filtration process in which both fine and coarse particles are removed from liquids. Filter uses gravity to remove heavier solids before filtration of the liquid through a horizontal bar type screen. Chain driven flights operating on a time-lapse sequence pass under the filter and remove deposits from the underside of the screen and the area beneath it. The flights carry particles to a device where they are cleaned. The filtered material then drops into a tote box for disposal. Filter is available in several sizes, flows and capacities. **Industrial Filtration Co.**, Dept. U-471, Lebanon, Ind.

Circle No. **11** *on Reply Card*

GENERATOR-INDICATOR

Multiple signal generator is available with a matched cathode ray indicator. Combined instruments are provided in one cabinet or ready for rack mounting. Generator, called Servoscope, provides



sinusoidal modulation in a suppressed carrier envelope or square wave patterns. By means of these signals and the indicator, gain and phase shifts of ac carrier and dc servosystems are measured. Four models offer frequency ranges from 0.001 to 60 cycles per second. Cathode ray indicator is designed for peak performance with any

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Servoscope model. Instruments incorporate a 5-inch, long-persistence cathode ray tube (for very sharp photographs), associated power supply and directly coupled deflection amplifiers. **Servo Corp. of America,** 20-20 Jericho Turnpike, New Hyde Park, L. I., N. Y.

Circle No. **12** *on Reply Card*

PRINTER AND PACKAGER

Automatic imprinting of complete descriptive data, government specifications, trademark design or other data on heat sealed paper or film packages, in addition to counting and packaging operations, are uses of new machine. The unit forms, fills, imprints and counts packages from 2 by 3 inches to 6 by 6 inches at rates from 40 to 80 per minute, depending on material used and object being packaged. Flexibility is achieved by use of Markem masterplates, typebars,

and rubber printing plates which can be changed with imprint requirements. Automatic synchronization of printing head with variable feed of machine assures exact registration. Inks are specially formulated to produce clear, durable imprints and are available in numerous colors. Finished packages fed out of the machine in a die-cut ribbon can be separated into individual packages or accordion folded. **Packmaster,** 1056 Home Ave., Akron 10, O.

Circle No. **13** *on Reply Card*

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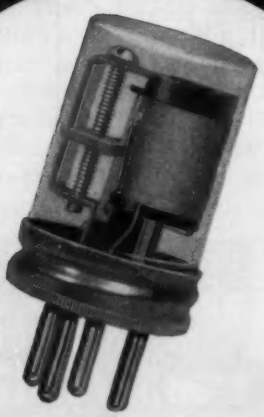

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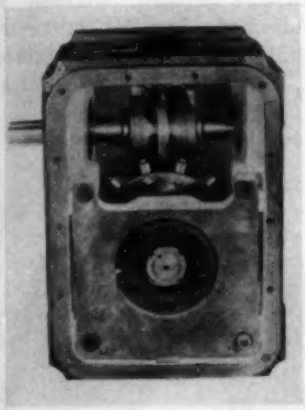


Roller Gear Drive

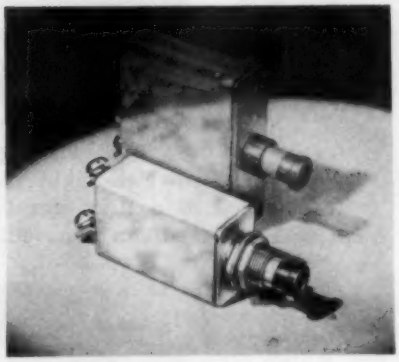
Four, six and eight-stop roller gear drive units with and without housings are among precision indexing drives available from stock. Roller gear drive is high-speed cam-indexing mechanism designed for inclusion in automatic production machinery employing dial feeds, roll feeds, carriers and chain, or other types of intermittent feeding methods. It permits operating speeds up to 1000 indexes per minute while maintaining precision without auxiliary locating or locking devices. Drive requires no maintenance for at least 8000 hours operation. **Ferguson Machine & Tool Co.**, P. O. Box 191, St. Louis 21, Mo.

Circle No. **14** *on Reply Card*

Metallized Paper Capacitors

Designed for reliability in high temperature operation, metallized paper capacitors are rated for operation at 125C without voltage derating. Capacitors withstand dielectric test of twice rated voltage. Other features include self-healing dielectric, complete hermetic sealing with glass-to-metal solder-seal terminals, and corrosion resistant cases. Both standard wire leads and solder tab terminals are available. Capacitors are used in military electronics and allied industrial applications such as control devices. **Sprague Electric Co.**, 405 Marshall St., North Adams, Mass.

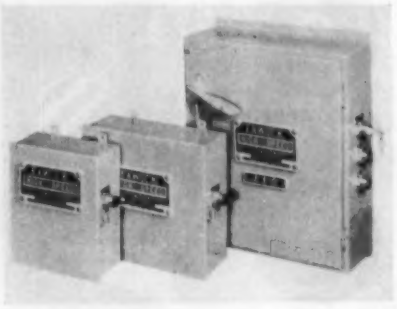
Circle No. **15** *on Reply Card*



Circuit Breaker

Miniature, trip free aircraft circuit breaker has conventional button action in which button emerges automatically and indicates tripping. Reset is manual. Disk type thermal element with double break and wiping contacts assures permanent precision calibration. Unit has high rupture capacity and handles over 2000 amp, 120v ac, 400 cycles per second and 6000 amp, 10v dc. Miniature circuit breaker is available in ratings from 5 through 35 amp. **Spencer Thermostat Div., Metals & Controls Corp.**, Attleboro, Mass.

Circle No. **16** *on Reply Card*



High-Speed Clutch Controls

Designed for installation on new or old presses, high-speed clutch controls are equipped with pneumatic clutch and brake. Available in three enclosure sizes, equipment provides nonrepeat protection and functions of inching, single stroke, and continuous operation. Selection is controlled by positioning of exterior oil-tight selector switch. Small, basic control is designed to meet average requirements of high-speed press. Medium size control may be equipped for timed inching or with Size 1 magnetic motor starter. Large size incorporates control for press clutch and brake, Size 1 starter for press drive motor and externally operated, cover-interlocked disconnect switch. Optional functions of hand-foot, semicontinuous, and timed-inching are available on large size panel. Each operating switch or pushbutton is oil-tight and sealed to prevent internal clogging and to make it externally spark-proof. Dual voltage (220 to 440v) primary transformers are provided. Air solenoid operates on 110v ac from transformer. Miniature relays are controlled from rectified 90v dc circuit. Double relay is used to control air valve solenoid. Blocking rectifiers are used across ac air valve sole-

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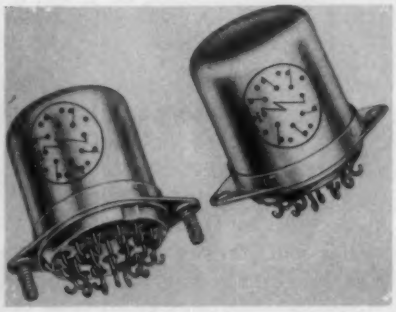
noid coil to reduce arcing at relay contacts and provide more consistent drop-out time of solenoid. Controls are available as individual units or as component part of package unit for conversion of presses to pneumatic clutch and brake. **Fawick Airflex Div., Fawick Corp.,** 9919 Clinton Rd., Cleveland 11, O.

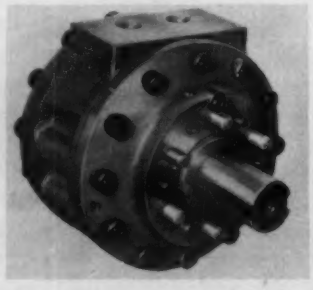
Circle No. **17** *on Reply Card*



Sealed Relay

Six pole, double-throw relay withstands 0 to 2000 cycle vibration to 30 g and withstands 60 g shock without contact opening. Unit is available for both 85C and 125C ambients. Nominal coil voltage is 26.5v dc. Relay features rigidity for high vibration and shock, high contact pressures, low contact bounce, high contact over travel, and absence of internal gaseous materials which might vaporize and cause contact unreliability. **Struthers-Dunn Inc.,** Pitman, N. J.

Circle No. **18** *on Reply Card*



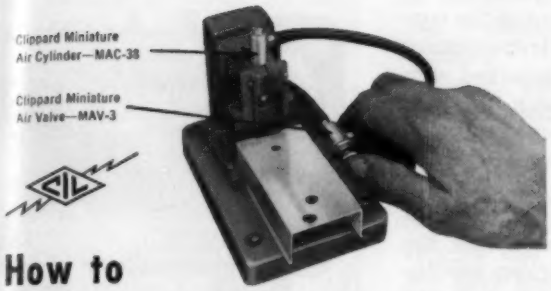
Rotary Actuator

Device for providing torque for revolving, opening, closing, lifting, pushing and pulling by means of reciprocating rotary power is called the AE Roto Jack. Actuator consists of a cylindrical housing with end caps in which is mounted a rotating shaft with an attached vane. Hydraulic oil up to 1000 psi or lubricated air under pressure moves the vane. Complete rotation of the vane is limited by a stationary inside stop which allows a 300 degree movement of the shaft in either direction. Speed of the shaft is determined by the capacity of the fluid pressure source, usually a vane or gear pump. Magnitude of the torque depends on the pressure exerted on the vane, and is 10,000 inch-lb at 1000 psi. Roto Jack can be face mounted, or, by addition of a bracket, flange or foot mounted. **American Engineering Co.,** Aramingo Ave. & Cumberland St., Philadelphia 25, Pa.

Circle No. **19** *on Reply Card*

Air Amplifier

Used with air plug and air ring gages as well as gaging fixtures for gaging single or multiple dimensions, back pressure air comparator can be co-ordinated to indicate point at which electrical contact is made or broken, turn lights on and off, or energize switches, as required. In operation, a filtered air supply, regulated at a constant pressure, enters the gage through the metering orifice in the adjustable compensator, passes through the automatic orifice, and exhausts from the nozzles in the pneumatic member. Differential pressure across



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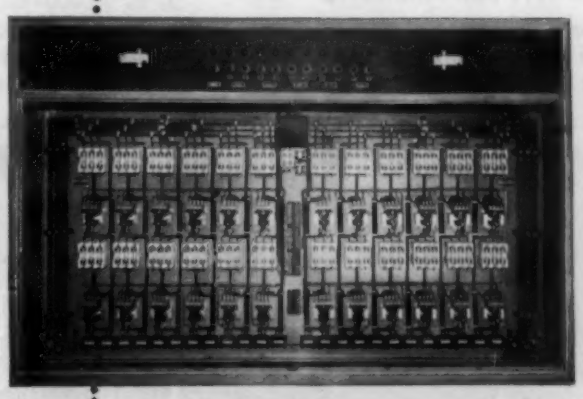

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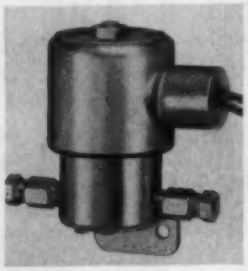
the metering orifice also exists across the bellows, which operates the orifice to maintain the differential constant. Any tendency to change flow from the nozzles closes or opens the automatic orifice to maintain constant flow rate. Unit can be varied to suit moderate production runs of precision parts or be set to a predetermined magnification with no change of parts. **Sturdy Tool & Gage Co.**, 14520 Schaefer Highway, Detroit 27, Mich.

Circle No. **20** *on Reply Card*



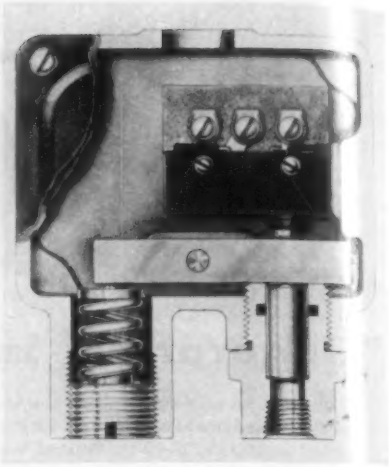
Noiseless Solenoid Valve

Electropneumatic valve is electrically operated air valve of the stop and waste type, designed to handle air only at supply pressures up to 25 psi. It can be used in the control line of a pneumatic instrument and be electrically interlocked with a fan motor to cause a valve or damper to assume its normal position when the fan is stopped. Valve will pass air when its coil is energized and will waste air from its outlet port when the coil is deenergized. Air connections are ⅛-inch NPT and electrical leads are 12 inches long. Coils can be supplied for 115, 208, 230, or 440 volts. Spring, armature and guide tolerances and material specifications are closely held to prevent ac hum. **Powers Regulator Co.**, Dept. ANC, Skokie, Ill.

Circle No. **21** *on Reply Card*

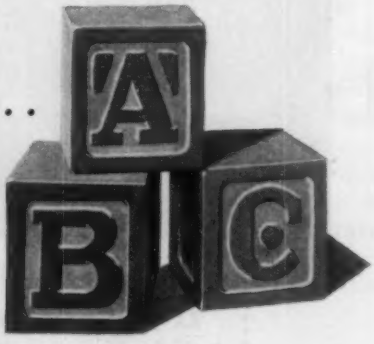
Piston Type Pressure Switches

Designed for high speed, automatic, heavy metalworking duty, piston type pressure switches accurately sense any system pressure over an adjustable range of 35 to 12,000 psi. Proof range of units is 4500 to 20,000 psi. Piston bore and piston are honed and ground to achieve uniform repeat



accuracy. Sealed piston is used to simplify installation and eliminate need for drain return piping. Generous piston travel prevents undesirable actuation from line surges, jarring or vibration. High proof pressure is protection against damage from excessive line or surge pressures. Switches will actuate an electric circuit at any predetermined point on increasing or decreasing pressure. Fixed actuation value varies from 15 to 1000 psi. Switch has an ex-

as basic as . . .



Designed, developed and constructed for maximum versatility, MAY-FRAN conveyor components now provide users with the ultimate of flexibility. Pre-fabricated conveyor sections can be furnished rapidly and inexpensively. Sections can be assembled to form virtually any type of hinged-steel belt conveyor for handling stampings, formed metal parts, forgings, automotive scrap, chips and turnings and many other miscellaneous products.

Straight sections . . . concave or convex curved

Now you can buy CUSTOMIZED conveyors in pre-fabricated STANDARD sections

MAY-FRAN ENGINEERING, INC.

6276-MF

1761 Clarkstone Road • Cleveland 12, Ohio

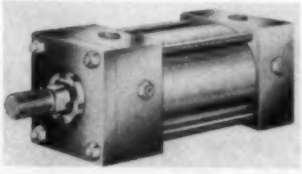
ternal adjustment screw for field setting which is locked in place to avoid its accidental disturbance. **Barksdale Valves,** 5125 Alcoa Ave., Los Angeles 58, Calif.

Circle No. **22** *on Reply Card*

Rotary Hopper Feeding System

Hopper and power feed tracks feed parts three to five times faster than by hand. System is available with as many as four feed tracks. Rated output of illustrated unit is 4500 corrected parts per hour, per track. In addition to feeding, installation can be used in conjunction with sorting, counting and inspection operations. Unit operates on a fully enclosed, continuous duty motor equipped with a slip clutch for overloads. Twelve-pitch gears, mounted on ball bearing shafts, are used throughout. Gears and bearings operate in an oil bath. Hopper has three-point mounting for easy installation on rough or uneven surfaces. Collector ring is adjustable for best feeding angle. **Feedmatic Inc.,** 22519 Telegraph Rd., Detroit 19, Mich.

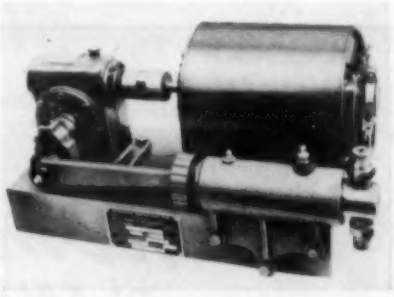
Circle No. **23** *on Reply Card*



Air Cylinders

Available in 11 bore sizes from 1½ through 14 inches, air cylinders have 21 types of mountings. Square end units feature brass tubes to eliminate corrosion, removable bronze cartridge containing wiper and rod packing, and cold rolled steel end plates. Chrome plated rod has four wrench flats and is available in optional sizes. Pistons and tie rods are secured with lock nuts. On cushioned models, cushions float on O-ring for accurate self-alignment. Cylinders can be supplied with either single or double-rod ends. **S-P Mfg. Corp.,** 12415 Euclid Ave., Cleveland 6, O.

Circle No. **24** *on Reply Card*



Proportioning Pumps

Designed for all general water treating requirements, controlled-capacity proportioning pumps are

sections . . . take-up and powered end sections can be furnished to meet specific needs as pertain to conveyor belt width, physical limitations as well as required volume and load capacities.

Once installed, a **MAY-FRAN** conveyor can be dis-assembled and re-assembled in another plant location . . . quickly, easily and with minimum down-time. In addition, conveyors can be lengthened, shortened or modified in almost any way at minimum cost.

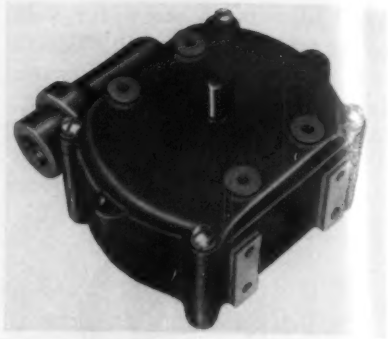
MAY-FRAN . . . a name long recognized in the materials handling field . . . is first again with *standardized* components for your *customized* installation.

made in simplex and duplex types for feeding up to 18.6 gph with maximum discharge pressures up to 800 psi. Among features of pumps are packing gland with external adjustment for positive packing compression, steel cross head running in precision machined bronze guide, forged or stainless steel liquid end, ground and polished stainless steel piston, and hardened and ground stainless steel valve balls spring-loaded for instant response. Connecting rod bearings are hardened and ground pins running in grease-lubricated needle bearings. **Philadelphia Pump & Machinery Co.**, 1513 Race St., Philadelphia, Pa.

Circle No. 25 on Reply Card

AC Rotary Solenoid

Designed for 60 cycle ac operation, rotary solenoid can be operated by standard voltages without use of rectifiers, transformers, etc. Rotary movement produced at the



shaft eliminates need for counterbalancing the spiral action. Torque developed by solenoid provides force characteristics of conventional linear type solenoids, but permits installation without levers and linkages. Rotary solenoid is a toroidal coil system wound on a stator and a shaft mounted rotor. When energized, magnetic field causes rotor and shaft to turn. Because of rotary design, solenoid is unaffected by vibration and shock. Eight basic sizes afford variety of torque values from fractional inch-lb to 62.5 inch-lb at maximum stroke on continuous duty models. Stock models give 20, 30 and 45-degree rotation. Other rotation angles up to 60 degrees are available. Standard electrical rating is 115v, 60 cycle ac. **Leetronics Div., Lee Spring Co. Inc.**, Dept. 25, 30 Main St., Brooklyn, N. Y.

Circle No. 26 on Reply Card

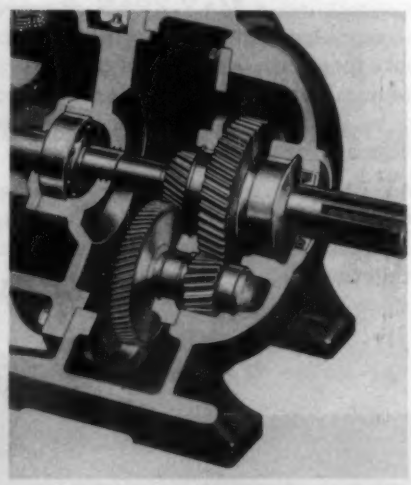
Hammond
of KALAMAZOO
AUTOMATION

• Chamfering Piston Skirts
• High Production • Quality Control

Our engineers are specialists in all branches of finishing—They have the "Know-How," and you are invited to consult with them on your particular polishing, buffing, finishing, or deburring problems.

Other parts are being "Automated" on Hammond Automatics.

Hammond Machinery Builders Inc. 1650 Douglas Ave. • Kalamazoo, Mich.

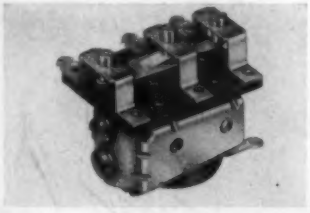


Gear Motor Line

Among features of line of gear motors are gear hardness and new pinion construction. Parallel shaft

units have gears machined to close tolerances from steel. Electrical types include elevator and hoist, slip ring, torque and multi-speed motors. Gear motor capacities range from 1 to 150 hp. Mechanically, units can be supplied in various types of enclosures, either with feet or with flanges for mounting horizontally or vertically. Optional accessory equipment includes brakes and zero speed switches. High speed pinion is locked to motor shaft. Pinion shaft is splined and drawn into a recessed motor shaft fitting by a threaded coupling nut. Self-splining action of pinion shaft as it is drawn in assures perfect alignment and a rigid lock which prevents play or creep, even under heavy reversing service. Pinion is removed for ratio change by backing off right- and left-hand threaded locking nut. **Howell Electric Motors Co.**, Howell, Mich.

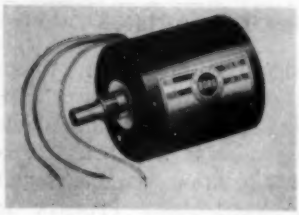
Circle No. **27** *on Reply Card*



Miniature Relay

Small, sensitive relay features easy adjustment over a wide range. Relay occupies 1⅛ by 1 7/32 by 1¼-inch space, and weighs 1½ oz in an SPDT contact arrangement. Unit is set to operate on 10 milliwatts, but it can be adjusted down to 2 milliwatts, or any desired pick-up or drop-out by means of fine screw contacts. Life expectancy is 250,000 operations at a contact rating of 1.5 amp. All contacts are above ground, and flexible pigtail connections which might cause adjustments to change are eliminated. Three standard coil resistances are available: 4000, 6500 and 10,000 ohm. Maximum coil rating is 3 w. Temperature range is −55C to 85C. Units are available in open types, dust tight or hermetically sealed enclosures. **Advance Electric & Relay Co.**, 2435 N. Naomi St., Burbank, Calif.

Circle No. **28** *on Reply Card*



Ten-Turn Potentiometer

An addition to the Micropot series, new ten-turn potentiometer is designed for original equipment manufacturers of precision electrical devices. Lead wires are used instead of terminals, permitting flexibility of application and ease of installation without changing the present wiring system. Leads are 9 inches long, flexible and color coded for easy assembly. Rear shaft extension is optional for both single units and ganged installations. Shaft is supported on two bearings. Standard resistance values are from 50 to 100,000 ohms. **The George W. Borg Corp.**, Janesville, Wis.

Circle No. **29** *on Reply Card*

When you think of finishing & deburring

think of Hammond

70 years building machinery has provided us with a bank of "Know-How." Our business is to share this with you, as we have with hundreds of America's leading manufacturers.

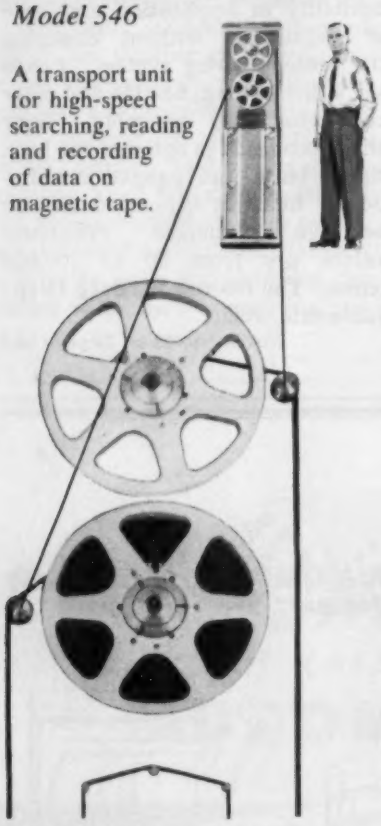
Your finishing problem is one our engineers will study to determine what savings are possible when employing modern Semi-Automatics, Automatics or Automation methods.

Hammond Machinery Builders
1650 DOUGLAS AVENUE • KALAMAZOO, MICHIGAN

DataReader

Model 546

A transport unit for high-speed searching, reading and recording of data on magnetic tape.



End-of-tape sensing

Slotted, hollow guide shafts, one adjacent to each tape reel are constantly subjected to a vacuum which is maintained as long as normal tape is passing over, and sealing the shaft openings. Perforated leaders at either end of the tape interrupt the vacuum and stop the tape reels. This feature also provides an automatic stop in the event of tape failure.

PERFORMANCE:

RAPID START—STOP—REVERSE—from stop to full speed in 6 milliseconds.

HIGH TAPE SPEED—optional single speed of 30, 40, 50, 60 or 75 in/sec.

TWO-DIRECTION SEARCH—either direction, automatically at full speed.

REMOTE OPERATION—forward, reverse, stop, rewind and selection of reading and writing.

VACUUM COLUMN TAPE CONTROL—provides strain-free tape feed over entire length of tape.

RAPID REWIND—2400 ft. of ½" or ¾" tape in 3 minutes.

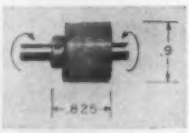
FOR FURTHER INFORMATION WRITE
ElectroData Corporation
Component Sales Division
460 No. Sierra Madre Villa
Pasadena 15, Calif.

ElectroData

An Affiliate of
CONSOLIDATED ENGINEERING CORPORATION
OF PASADENA, CALIFORNIA
ElectroData Corporation maintains a nationwide sales and service organization.

In-Line Drive Clutch

Line of miniature magnetic clutches features a direct in-line drive. All drives are available in three models; two are for continuous rotation and one for single turn adjustment. Primary function of the direct in-line clutches is to couple opposing shafts. A universal joint is provided for ease of coupling alignment and operation. Clutch assembly weighs approximately 1 oz; it can be supplied to operate at voltages from 6 to 30 dc or rectified ac, with under 1 w power consumption. Clutches transmit from less than 1 oz-inch to over 15 oz-inches from engagement to disengagement. They have zero clutch slip when operated within rated conditions. Clutch drive has been used in bidirectional electrically controlled speed changers, servomotor positioning, and positioning and positive switching for rotating devices. **Electronic Mfg. Engineers Co.**, 2410 Beacon Ave., Seattle 44, Wash.



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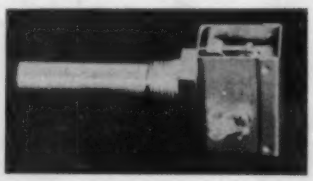


Temperature Control Units

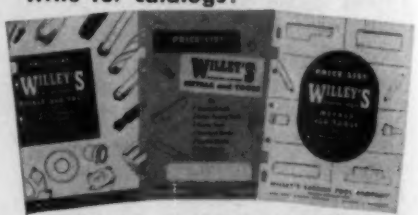
Local bulb snap action thermostats are designed for accurate temperature control and overheat detection at heavy electrical loads of up to 20 amp. Units are available in combinations of head styles and mounting arrangements for use in gases, liquids or solids and in many types of equipment. Starting with basic heat sensing unit (a bellows assembly and rod linkage enclosed in liquid filled cylindrical housing), user can choose from among four basic thermostat features and several special modifications. Four basic building-block features are: temperature

FOR THE BUSINESS END OF THE Automatics

WILLEY'S TUNGSTEN CARBIDE TOOLS

For **PROFIT PRODUCTION** and **LONG, NON-STOP** runs... Willey's Tungsten Carbide Tools best meet the demands of Modern Automation.

Write for catalogs:



Specialists in Preformed Carbide Shapes and Tools to Blueprints

WILLEY'S CARBIDE TOOL CO.
1340 W. Vernor Hwy. • Detroit 1, Mich.

range, type of switch, type of enclosure or head for the switch, and type of mounting arrangement. Temperature set point of all thermostats is field adjustable, with friction locking devices on adjusting screws to resist vibration. Torsion spring arrangement permits entire switch to rise under excessive thrusts from actuating rod, and prevents switch damage in event thermostat is overshot above its set point. Sensing bulb of unit is 5/8-inch diameter, 3½ inches long. **Fenwal Inc.**, Ashland, Mass.

Circle No. **31** *on Reply Card*

Gasket Mounted Pressure Switch

New switch is designed for applications on hydraulic presses, production and processing machinery, machine tools and other similar oil-hydraulic equipment. A special subplate is available with the switch to permit mounting in applications where a machined pad is not provided. Switches are available in three models for 100 to 1000 psi, 100 to 2000 psi, and 500 to 5000 psi ranges. Pressure settings are adjustable. Overall dimensions for the three models are the same—3⅞ inches wide by 7 11/16 inches long by 2 inches deep. Nominal current ratings are 10 amp at 110 to 125v ac for the 100 to 1000 psi size, 5 amp at 220 to 250v ac for the 100 to 2000 psi size and 3 amp at 440 to 460v ac for the 500 to 5000 psi size. **Vickers Inc.**, 1400 Oakman Blvd., Detroit 32, Mich.

Circle No. **32** *on Reply Card*

AFFILIATE OF GENERAL CERAMICS CORPORATION

Magnetic Amplifiers · INC

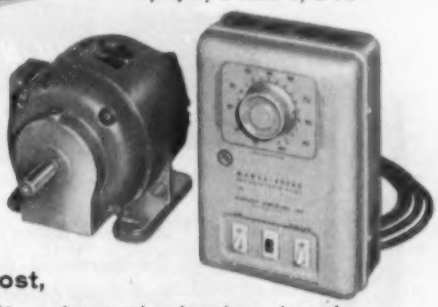
—announces its new

VARIABLE SPEED DRIVE

MAGNE-SPEED*

SIZE II —
3/4, 1 and 1-1/2 HP

SIZE I —
1/4, 1/3 and 1/2 HP



Stepless, instant starting, compact, 50:1 speed range, good regulation without tachometer, long life, virtually maintenance free service, low cost, fast response, reversibility, dynamic brake, local or remote control. Write for Bulletin S580-5-55.

Other MA Products and Services

Magnetic Servo Amplifiers
Transi-Mag * Amplifiers
Analog Computors
Photoelectric Controls
DC and AC Regulated Power Supplies

* Trade Name

Application engineering and conversion of tool machines and production processes to automatic control.

Magnetic Amplifiers • Inc
Tel. CYpress 2-6610 • 632 TINTON AVE., NEW YORK 55, N. Y.

MARSH *Mastergauge*

Always the best of the better gauges, Mastergauge has been given *plus* features that further lengthen its lead.

A still better tube construction: Socket, tube and end piece are now all fused into *one* leak-tight unit by the new Marsh "Conoweld" process.

A still better case: New copper clad wrought steel "Marshalloy" case has the corrosion resistance of pure copper; weighs one third as much as cast iron, and is *four times* as strong.

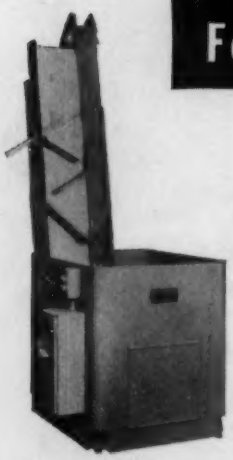
An even finer movement: Further refinements are added to the rugged, corrosion resistant, virtually frictionless stainless steel and monel Mastergauge movement. A typical refinement is the "coined" (extruded) sector gear which contributes extra strength and precision.

Where only the best is good enough—in the most critical industrial refinery and oil country services —"Mastergauge" is your instrument.

WRITE FOR NEW CATALOG

MARSH INSTRUMENT CO. Sales affiliate of Jas. P. Marsh Corporation
Dept. X, Skokie, Ill.
Houston Branch Plant: 1121 Rothwell St., Sect. 15, Houston, Texas
Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alta.

DO YOU HAVE Feeder Problems?



Above is a typical Elevating Feeder. It will deliver either to right or left hand or both.

And who doesn't these days—with the increased demand for faster and more automatic operation of machines and assembly lines.

You will find that FEEDALL Automatic Feeders will solve many of your Feeder Problems.

FEEDALL Feeders are made with Blade, Vibratory, Rotary or Elevating Feed as may be best suited to your requirements. Specifications, rate of feed, etc. are variable as may be needed.

Why not tell us your Feeder Problems and let our engineers help you.

FEEDALL INCORPORATED
WILLOUGHBY, OHIO

AUTOMATION patents

Copies of patents are available at 25 cents each from the Commissioner of Patents, Washington 25, D. C.

Components

CENTRIFUGAL SWITCH

Switching device contains conductive fluid which closes an electric circuit when at rest but upon sufficiently rapid rotation is moved by centrifugal force and the circuit is opened. Patent 2,714,640 by Robert G. Ferris, assigned to the United States of America.

SPRING RETURN MECHANISM

Means for returning a rotatable member to a neutral point when it has been positioned either side of that point. Two spiral springs are used. Patent 2,714,000 by Thomas J. O'Connor and Clayton H. Williams, assigned to Bell Telephone Laboratories Inc.

♦ ♦ ♦

Handling

APPARATUS FOR ORIENTING HEADED ARTICLES

Apparatus for orienting headed articles which are fed thereto in random endwise orientation comprises a pair of escapement devices having relative lateral movement with respect to each other. Patent 2,713,930 by Hermann H. Koch, assigned to the Budd Co.

CONVEYOR DISPATCH SYSTEM

For a conveyor system using self-propelled electrically powered units, automatic stopping, starting, an operation of track switches is provided through use of a control conductor along the conveyors contacted by a collector means on the units. Patent 2,714,355 by Alfred D. Benson, assigned to Mechanical Handling Systems Inc.

MACHINES FOR ACTING AT SPACED POINTS ON STRIP OR LIKE MATERIAL

Means for moving a tool to act on a continuously moving strip has additional means responsive to the speed of the strip for controlling duration of the tool movement. Patent 2,716,450 by George G. Nicholson, assigned to Davy & United Engineering Co. Ltd., Sheffield, England.

Measuring

LIQUID LEVEL MEASURING APPARATUS

Device for indicating liquid level in a vessel comprises a source of radiation carried by a float and a radiation detector movable vertically. Patent 2,714,167 by Gerhard Herzog, assigned to The Texas Co.

WEIGHING APPARATUS

Combination of means is used to weigh material intermittently and discharge weighings to a reservoir from which a feeder discharges material at a variable rate which is determined by the amount of material in the reservoir. Patent 2,714,472 by Philip B. Richardson, assigned to Richardson Scale Co.

NON-CONTACTING THICKNESS GAGE

Means for indicating variations from desired thickness of a moving strip of sheet material utilizes two beams from a radiation source, two ionization indicators and a standard measuring plate. Patent 2,714,669 by August T. Wuppermann, assigned to Exatest Gesellschaft fur Mebtechnik mit beschrankter Haftung, Leverkusen, Germany.

♦ ♦ ♦

Packaging

CAN PACKAGING MACHINE

Can handling means receives cans in single file and discharges cans in stacked rows bounded by a given rectangular geometric figure. Cans are discharged to carton supporting can receiving forms. Patent 2,713,959 by Frank U. S. Gilbert, Joseph Harrison Jr., and George A. Kruse, assigned to the Cleveland Cleaner & Paste Co.

PACKAGING APPARATUS

Apparatus for packaging containers in cartons includes means to automatically orient the containers on a feeder conveyor into groups which can be picked up by a suspension means and dropped into the carton. Patent 2,714,481 by John K. Bruce and George L. Frank, assigned to Bruce Engineering Corp.

♦ ♦ ♦

Process Design

METHOD AND APPARATUS FOR CASTING STRIP METAL

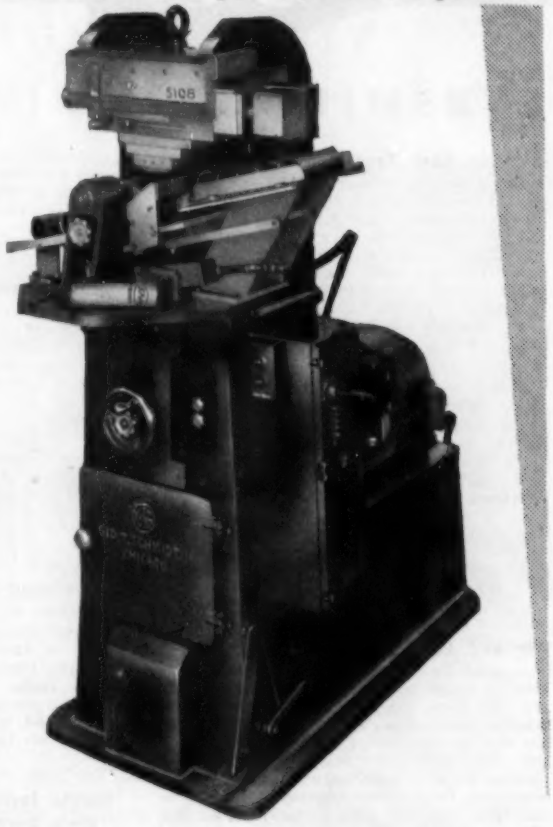
An endless core is rotated through a container of molten metal and the metal deposited on the core is stripped from it to produce a metal strip. Patent 2,714,235 by Joseph B. Brennan.

METHOD OF HOT ROLLING STAINLESS STEEL

Stainless steel is hot rolled through plurality of passes without reheating by coating the steel with an insulating ceramic refractory which is solid at the hot working temperature. Patent 2,708,379 by Matti H. Pakkala and John L. Scarry, assigned to U. S. Steel Corp.

WOW AUTOMARKING

for faster, more uniform, less expensive identification of products and parts



The tube marker shown here, designed and built for a large automotive manufacturer, is a marvel of modern production efficiency. Tubes are given uniform and accurate identification, with a speed that lowers the cost-per-impression to a minimum.

2500 to 3000 Parts Per Hour

This JIC hydraulically-operated machine rolls a trademark and part number on mild steel thin walled tubes at a rate of 2500 to 3000 per hour, depending on length of marking.

Fully Automatic

A Geneva-type feeding mechanism receives parts from preceding operation and deposits them in a rotating spider. A retractable arbor supports parts during marking, after which spider carries them to discharge chute. Operation is *fully automatic*. Machine will not start marking cycle without work at station. Hydraulic action insures clean marking of uniform depth.

GTS engineers have designed many such Production Marking Machines for industry. They reduce marking costs to a fraction of those involved in old fashioned methods. GTS sales engineers will be happy to call and confer with you on your specific problem.

IF IT'S WORTH MAKING, IT'S WORTH MARKING.

GEO. T. SCHMIDT, INC.
4108 Ravenswood Avenue
Chicago 13, Illinois

new CATALOGS AND LITERATURE

Electric Fork Trucks

Lewis-Shepard Products Inc.—Fall issue of the "Lever," company magazine, contains information on numerous models of electric fork trucks designed for various industrial applications. Special attention is called to the new Hydrafork which requires minimum aisle space because of hydraulically operated forks controlled from the cab. Photographs in 16-page magazine illustrate fork trucks in actual applications.

Circle No. 33 on Reply Card

Wire Wound Resistors

Precision Inc.—Eight-page brochure describes various types of wire wound resistors. Alloy characteristics charts list symbols, alloys, trade names, nominal temperature coefficients and guide to proper selection. Brochure covers fixed, adjustable, tapped multisection, pigtail terminal, and ferrule terminal vitreous enamel, as well as wire wound precision resistors, and includes photographs of each type.

Circle No. 34 on Reply Card

Air and Electric Tools

Ingersoll-Rand Co.—Devoted to problem of running nuts, bolts, cap screws, and other type fasteners, comprehensive 52-page catalog contains numerous application photographs. Air and electric impact tools, multicycle electric tools, and other company products are illustrated, with specifications and accessory equipment listed. Case histories are given to illustrate time and cost savings through use of company tools.

Circle No. 35 on Reply Card

Gear Motor Combinations

Transicoil Corp.—Servosystem designers are provided with delivery date information in four-page booklet on gear motors and geared motor-driven induction generators. Gear ratios for available standard types of control motors are covered. Special servo assemblies useful in field of automation are illustrated and briefly discussed.

Circle No. 36 on Reply Card

Automation in Bottling Plant

ACEC Electric Corp.—First issue of "Motorization" includes illustrated article on mineral water plant in France which uses automatic machines linked by a mile of motor driven conveyors to maintain a production rate of 800,000 bottles per day. Magazine, which is devoted to progress in use of electric motor unit drives by industry, also covers motorization in glass and bottle manufacture, motorization of wool processing machines, determination of size of geared motor variator suitable for driving a glass annealing furnace, and standardized solution for hauling and towing problems through application of capstans.

Circle No. 37 on Reply Card

Automatic Palletizer

Food Machinery & Chemical Corp.—Engineering, construction and operating information on automatic palletizer which palletizes cases in interlocking patterns is given in eight-page bulletin. Unit will palletize up to 36 cases per minute. Palletizer may be equipped to build a number of different patterns by turning a selector switch or inserting different plug-in cartridges. Arrangements are also available for automatic pattern selection. Among pallets handled by machine are wooden, fiber, disposable and other types. Photographs illustrate sequence of operations of palletizer.

Circle No. 38 on Reply Card

Boiler Plant Instrumentation

Hays Corp.—Line of power plant instruments and control systems is covered in 24-page catalog. Photographs of equipment such as combustion guide instruments; draft gages; flow, liquid level, temperature, pressure and testing instruments; and combustion control elements are included. Schematic diagrams illustrate stoker and gas fired boiler systems. Case history chart indicating problems of certain companies, number of boilers, boiler ratings, load swings, fuel and steam use, and results of using Hays instrumentation is given.

Circle No. 39 on Reply Card

Controlled Air Power Devices

Bellows Co.—Air motor which offers choice of five different integral valves and five bore sizes is discussed in eight-page, illustrated bulletin. Photographs and descriptions of drill press feeds, vises, rotary feed and index tables, self-contained drilling units, and valves and cylinders in various packaged air devices are also included.

Circle No. 40 on Reply Card

Textile Instrumentation

Brush Electronics Co.—Line of instruments engineered for textile field is described and illustrated in new brochure. Among devices covered is unit which measures and records longitudinal and lateral weight variations of picker-lap automatically, while lap is being processed. Tension analyzer which measures and records static and dynamic tension levels during routing processing of yarn and roving is also discussed. Imperfection counter which detects and automatically totals number of imperfections in yarn moving 100 yd per minute, and uniformity analyzer which measures and records nonuniformity of yarn, roving and sliver at speeds up to 300 yd per minute are illustrated.

Circle No. 41 on Reply Card

Flexible Metal Hoses

Atlantic Metal Hose Co. Inc.—Directed toward design, maintenance and purchasing departments, new bulletin covers corrugated flexible metal hose of annular and helical construction. Steel and bronze hose, with and without wire braid, couplings and assemblies are described. Engineering data including bending radii, bursting pressures and weights are given. Among applications of hose are vibration absorption, misalignment connecting, high pressure use, oil burner and gas furnace connections, high temperature lines, air line boosters, lubricating lines, equalizer connections, loading and unloading of light and semisolids, and for conveying compressed air, saturated steam, solvents, chemicals, refrigerants, gasoline, searching liquids, caustics and ammonia.

Circle No. 42 on Reply Card

Sampling Switches

General Devices Inc.—Three basic switch designs which are available with a variety of contact arrangements and integrated motor drives for military, scientific and commercial purposes, are discussed in four-page brochure. Photographs illustrate applications of switches in missile telemetering, signal simulation, amplifier drift compensation, automation, multichannel display, high speed relay programming, function gating and aircraft instrumentation. Performance chart indicates life of typical 60 contact, 300 rpm switch, covering one year's continuous operation and over 50 million revolutions.

Circle No. 43 on Reply Card

Gages for Industry

Instrument & Systems Div., Norden-Ketay Corp.—Photographs and specifications of Acragages, pressure gages which first featured bourdon tubes of extra length, integral assemblies of entire gage mechanism, and micrometer pointers with locking screws, are included in four-page brochure. Acragages are available with solid front cases, capillary bleeders, shockstop and diaphragm protectors. Brochure also contains brief descriptions of pneumatic transmitters, pneumatic receiver gages, low pressure gages and aircraft gages.

Circle No. 44 on Reply Card

Industrial Rubber Products

Thermoid Co.—Specifications and descriptions of 68 different rubber hoses for agricultural and industrial use are presented in eight-page catalog digest. Also included are data on conveyor belts, flat power transmission belting, multiple and fractional horsepower V-belts, chute lining, rubber sheet packing and industrial friction materials. Cutaway photographs illustrate hose, coupling and belt construction. Among hoses covered are types for air, ammonia, hydraulic, oil and gasoline, oil field, steam, water suction, welding, acid suction, butane and propane models.

Circle No. 45 on Reply Card

Drive Selection Catalog

Allis-Chalmers Mfg. Co.—Twenty quick-selection tables provide easy reference to constant speed V-belt drives in comprehensive, 74-page catalog. Information on design features, basic drive principles, technical data on sheaves, and discussion on economical, safe and dependable operation of V-belt drives are included. Among tables are recommended belt selections, recommended small sheave sizes, belt installation, arc of contact correction factor, locating sheaves of ¼-turn drives and sheave rim weight.

Circle No. 46 on Reply Card

Chipless Machining

Michigan Tool Co.—Machines for cold forming of toothed parts are discussed in eight-page brochure. Three sizes of machines available from company and numerous examples of machines in actual applications producing various toothed parts are included. Additional photographs illustrate typical parts formed on these machines and automatic equipment designed for the machines.

Circle No. 47 on Reply Card

Potting Connectors

Cannon Electric Co.—Illustrations and instruction material on method of potting connectors for sealing against moisture are included in 12-page bulletin. Items such as the way to mix the sealant, potting forms, types

of guns and various required time intervals are discussed. Bulletin follows necessary steps from beginning of potting operation through the complete job. Dimensions for resilient and plastic insert connector models designed for potting are also included.

Circle No. 48 on Reply Card

Radio and Electronic Parts Catalog

Allied Radio Corp.—Comprehensive, 342-page electronic parts catalog contains information on over 26,000 items. Items are covered for industrial maintenance, research and production requirements. Detailed listings of standard and special purpose electronic tubes, test instruments, voltage stabilizers, transformers, resistors, capacitors, printed circuit components, transistors, rheostats, relays, switches, rectifiers, fuses, tools, wire, cable, photoelectric components, nuclear instruments, sound-powered telephones, counters, program clocks, batteries, sockets, generators, power supplies and numerous other electronic equipment and components. A rotogravure section presents public address amplifiers in systems ranging from 8 to 80w. Sections are also devoted to high fidelity equipment, recording equipment, kits and technical books.

Circle No. 49 on Reply Card

Multidimension Gaging Machines

Pratt & Whitney Div., Niles-Bement-Pond Co.—Twelve-page brochure provides information on gaging machines designed to check many dimensions simultaneously. Three types of machines—manual, semiautomatic and fully automatic—are discussed, with specifications and photographs included. Machines will inspect up to 50 dimensions at rates up to 3600 pieces per hour. Sketches indicate possible combinations of indicator panel, gage head assembly, base unit and pedestal.

Circle No. 50 on Reply Card

Automatic Weldment Cleaning

American Wheelabrator & Equipment Corp.—New bulletin discusses automatic cleaning of rust, flux and spatter from welded pieces by abrasive blast cleaning. Case history on effect of automatic blast cleaning on work at large manufacturing shop, including illustrations of equipment and typical parts being cleaned, is given. Automatic blast cleaning in this case reduced weldment grinding time at least 75 per cent.

Circle No. 51 on Reply Card

Reducing and Regulating Valve

A. W. Cash Co.—Information on high pressure reducing and regulating valve is given in four-page bulletin. Included are photographs and cross-sectional engineering drawing, recommended uses, description of construction and operation features, capacity, rating and sizing charts and other pertinent information on valve. Valve was designed for hydraulic presses, hydraulic system die mold apparatus, pneumatic systems and similar applications.

Circle No. 52 on Reply Card

Differential Pressure Transducer

Moore Products Co.—Combination of Barton flow meter and Moore motion transmitter comprises differential pressure transmitter which is discussed in eight-page brochure. Schematic diagrams are used to illustrate flow meter and motion transmitter components. Operating characteristics and design features of both units are covered. Dimensions, standard ranges, performance data and design specifications are listed.

Circle No. 53 on Reply Card

Electronic Transformer Catalog

Triad Transformer Corp.—Among 685 items in transformer catalog are subminiature audio transformers, available in either hermetically sealed or open frame type, high fidelity output transformers, power components, geoformers, replacement power, audio transformers, dry disk rectifier transformers and television replacement equipment. Photographs of various models in series, specifications and power supply information are included in 32-page catalog.

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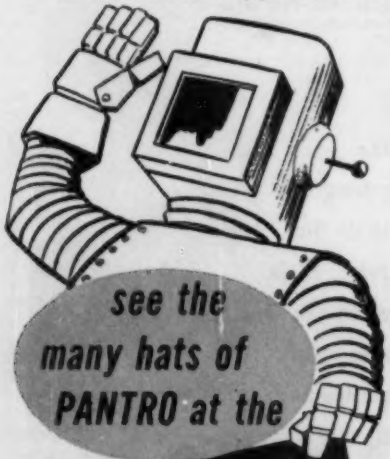

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Scale Models for Industry

Knight Models Inc.—Eight-page illustrated brochure discusses applications of three-dimensional scale models layout planning in industries such as aircraft, automotive, chemical, dairy, machine tool, power plant, printing and publishing, transportation and electronics. Models can be magnetized so that various layouts, building dimensions and bay sizes can be changed readily and studied to determine most effective arrangements. Brochure includes photographs of models used in design, layout, production planning and site development.

Circle No. 55 on Reply Card

Magnetic Transmission Equipment

Stearns Magnetic Inc.—Line of magnetic brakes and clutches are discussed in eight-page brochure. Design data, brake selection information, and clutch and brake torque considerations are covered. Photographs and specifications of various models are included in brochure. Magnetically released spring set disk brakes, magnetic pulleys, permanent plate magnets, automatic drum separators and lifting magnets are also illustrated.

Circle No. 56 on Reply Card

Gage Applications

Freeland Gauge Co.—Variety of standard and special gages and measurement control methods are illustrated and described in eight-page bulletin. Included are photographs of special and built-up gages, special air gage fixtures and unusual air gage applications designed for automotive, aircraft and metal-working industries. Among special applications illustrated are air gage spindle used to check four diameters simultaneously, flat air gage spindle used to check width of piston ring groove on automotive piston, air application to check male and female spherical radii for aircraft landing gear, and air gage spindle to check inside diameter at two places and squareness of bore at two places.

Circle No. 57 on Reply Card

Automatic Welding Equipment

General Electric Co.—Four-page brochure discusses automatic welding equipment designed for use on mild steel with CO_2, aluminum, stainless and other metals, heavy or light gage material continuous or tack welding and all position operation. Equipment is designed for consumable electrode, gas shielded welding. Control panel, wire feeder, torch, reel mount and power source are described. Diagram of typical automatic welding installation illustrates application of equipment. Specifications are given in chart form, and sketches give dimensions.

Circle No. 58 on Reply Card

Electronic Measuring Instrument

Fielden Instrument Div., Robertshaw-Fulton Controls Co.—Proximity meter which can detect change in temperature of 0.001 C, or variations as small as 0.000001-inch, is discussed in 28-page manual. Operating principle of device, based on electrical capacitance, is reviewed for nontechnical readers. Catalog describes applications of proximity meter as noncontacting micrometer, concentricity gage, surface finish gage, strain gage, torque meter, vibration meter, automatic weigher, breaking strain gage, paint or insulation thickness gage, micro thermometer, pressure gage, and moisture content or dielectric constant determinant. Technical data and performance specifications are included in a final section.

Circle No. 59 on Reply Card

Pyrometer Supplies Brochure

Arklay S. Richards Co. Inc.—Thermocouples, protecting tubes, thermocouple wires, extension lead wires, insulators, pyrometers and accessories are discussed in 16-page brochure on pyrometer supplies. Complete thermocouple assemblies in straight and angle types are illustrated and their specifications given in

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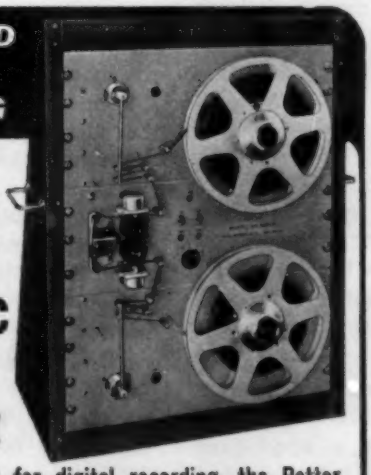

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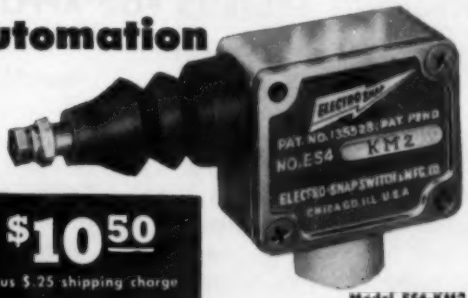

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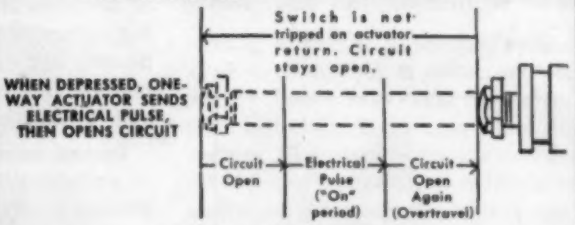
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AUTOMATION abstracts

SWITCHING SYSTEMS FOR APPLICATION

By JAMES L. WIMPEY
McDonnell Aircraft Corp.
St. Louis, Mo.

INTENT of this paper is to present a survey of switching systems. It is hoped that by bouncing around on the periphery of this vast field, one's memory may be refreshed concerning some old and some new techniques that may or may not be frequently discussed in relay circles, but yet, per chance, in some applications perform an equivalent function better.

The bounds or limits of the field of switching are difficult to define. There is implied definite states of being as *Open* or *Closed, Off* or *On,* 0 or 1 and so on, rather than continuous conditions. Any number of anomalies in definition may be raised.

Without attempting either to define or to limit the field, some of the functions which are often employed are: Wave form generation, as rectangular pulses, saw tooth waves and so on; memory or storage which may be for short, intermediate, or long periods and involves the retention of information for subsequent use; operations involving addition, subtraction, multiplication, and division; translation of information from one code to another; regeneration of signals in amplitude and wave form; delay, which may be thought of as a form of storage or memory; and timing. Some of these functions are simple—others result from fairly complex structures of simpler functions.

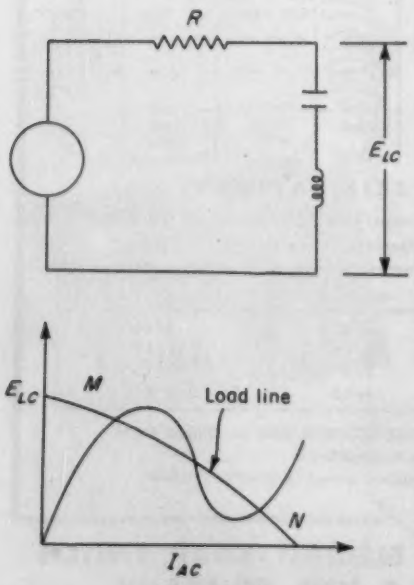

Fig. 1—Switching circuit employing the ferroresonant phenomenon

It is the object of this paper to discuss in general terms a survey of methods involving these switching functions with emphasis placed, not on design or analysis, but on performance, application, and limitations.

In the present state of the art of switching, the following list of devices perform in a specialized manner some of the functions that are considered within the field of switching: (1) Electromagnetic devices, (2) transistors, (3) electron tubes, (4) electromechanical types.

Electromagnetic Switch

Two types of magnetic switches will be mentioned. The first is a high frequency carrier switch based on the magnetic amplifier principle and the second a ferroresonant switch based on the nonlinearity of the magnetic core. The carrier type switch is a saturable core magnetic amplifier with a large amount of positive feedback. It is similar to the bistable electronic flip-flop in that both circuits are basically amplifiers with positive feedback or regeneration. A high frequency carrier provides the energy to lock one of the two cores into a saturation state.

Operation is based on the control of effective inductance by changing the degree of dc saturation of the core. If the core is unsaturated, there is a relatively high ratio change of flux linkages to change of coil current. The effective inductance of the coil is relatively high. If the coil should become dc saturated, small changes in current can no longer cause substantial changes in flux linkages and the effective inductance is therefore relatively low. The feedback magnetizing force must be great enough so that as the saturation of the core is approached or attained, the feedback magnetizing force will increase to such an extent as to pull the core into further saturation and lock it there. The carrier switches that have been developed employ 1.4 megacycle carrier frequency and operate at a maximum pulse rate of 400 kilocycles. These switches are primarily employed in binary counters, and pulse amplifiers for digital computers.

The Computer Research Corp. has developed a switch employing the ferroresonant phenomenon. Consider the circuit of *Fig.* 1. If the frequency and the voltage of the generator are properly chosen, the circuit has two distinct states, either of which can be maintained indefinitely. If L is an iron cored inductor, it will encounter ac sat-

uration over at least a part of the cycle if a strong enough magnetomotive force is applied. Upon saturation the effective inductance of the coil changes. Changes of 20 to 1 are quite common in some cores.

When saturation occurs in the coil, there exists a reduced inductance in series with a capacitor. When the proper value of ac current is flowing through the coil-condenser combination, the voltage across this combination, E_{LC} will be at the point N or M on the voltage current characteristic of *Fig.* 1.

If a second winding were applied to the core of inductor L, it is possible to raise the current in the circuit from point M to point N by the application of a dc trigger pulse which temporarily reduces the inductance of L and allows the current to jump to point N, where the current holds since the device is self latching.

Applications of this fundamental ferroresonant property are numerous. To mention a few, we have gates, counters, oscillators, subharmonic generators, and pulse generators. Typical limits for reliable triggering are from 1 microsecond to 4 microseconds.

Transistor Switching

Transistor switching techniques employ two basic types of transistors—the point contact and the junction types. Transistors of the point contact type have current gain factors greater than one in the positive emitter current region. If an external resistor is connected in series with the base electrode, a negative resistance characteristic will be obtained looking into the emitter terminal.

This characteristic may be explained in terms of the electrode current flow and current multiplication properties of the transistor. The current flowing into the base electrode is the algebraic sum of the emitter and collector currents, *Fig.* 2.* Since the collector current is negative and larger in magnitude than the emitter current in the positive emitter current region, the normal base current will also be positive. A positive in-

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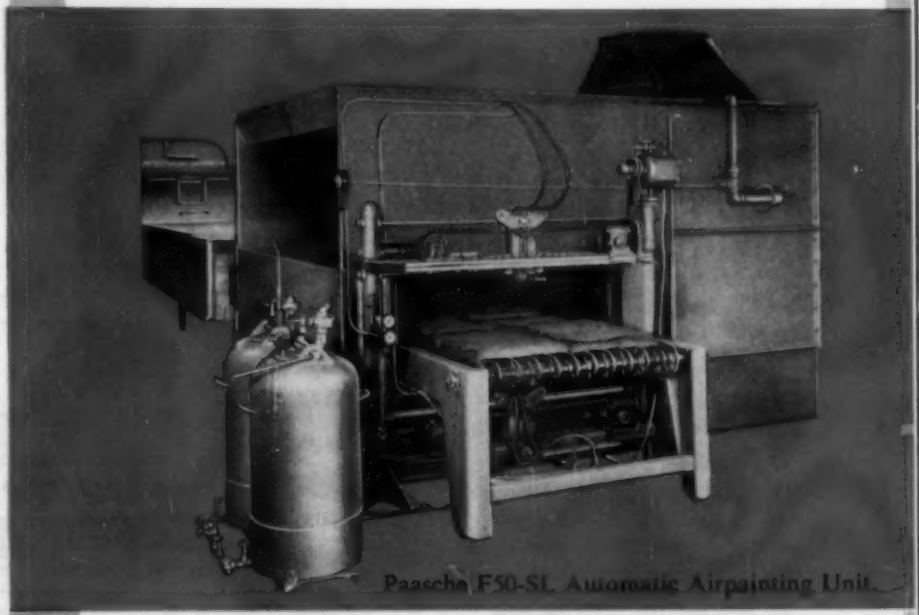

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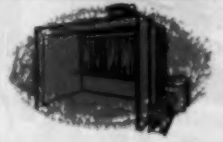

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crement of emitter current, therefore, will result in a larger increment of positive base current which by flowing through the external base impedance, makes the base more negative with respect to the emitter electrode. This causes an additional increment of emitter current to flow inducing an even larger positive base current.

This, in brief, is a regenerative process which gives rise to the negative resistance portion of the characteristic. This process will continue until, as determined by the external circuit parameters, the transistor enters the collector current saturation region with the characteristic slope again becoming positive. In applying the transistor to switching, we are interested in obtaining a stable peak turning point which occurs in the vicinity of zero emitter current.

The difficulty with present day point contact transistors is the fact that collector current flows with zero emitter current and may vary from 0.3 ma to 3 ma in acceptable units. Now, if a base re-

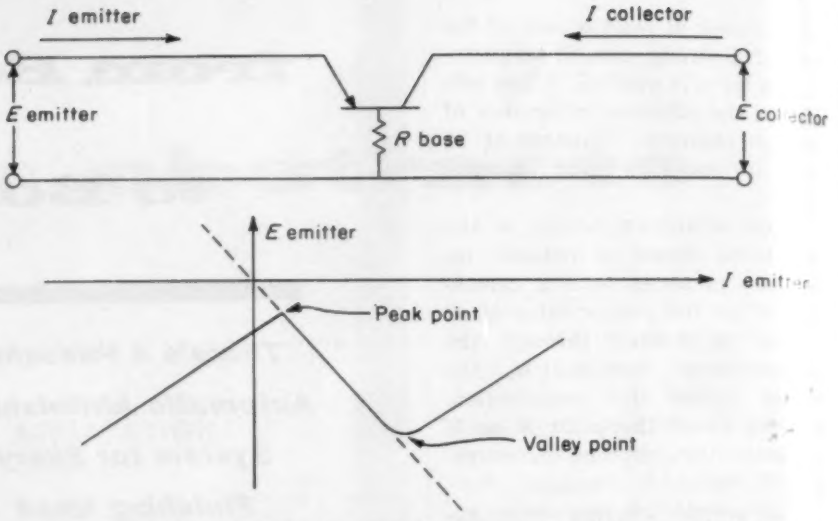

Fig. 2—Circuit demonstrating the electrode current flow and current multiplication properties of the transistor

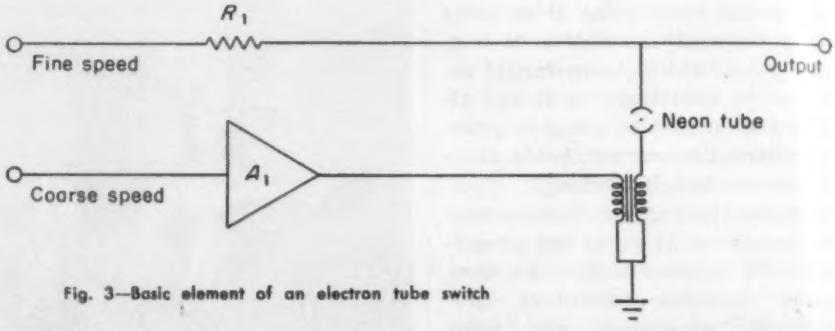

Fig. 3—Basic element of an electron tube switch

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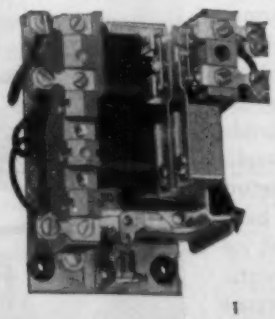

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sistor of around 5000 ohms is introduced in order to obtain the negative resistance characteristic necessary to make a switch, the peak turning point may then vary from 1.5 to 15 volts. Stabilization techniques have been devised to overcome some of these fundamental difficulties; however, there is much to be desired in peak turning point stability when the switch is subjected to high temperature. The lack of suitable trigger circuitry and the difficulty in obtaining a double ended symmetrical configuration, limits the use of the single transistor in certain applications.

Experience with small sample quantities of both point contact and junction transistors indicates that at present, the commercially available junction types are the more uniform in characteristics. Junction type transistors, however, do not display the negative resistance characteristics inherent in point contact but may become switches by use of regeneration or positive feedback techniques, such as the Eccles Jordan Multi-Vibrator. The response of the junction type transistor switch is limited to around 140 kc where the point contact is around 500 kc. Westinghouse Electric Corp. has a new transistor chopper capable of operating at frequencies up to hundreds of kilocycles, which opens up possibilities of designing servos with extremely fast response time.

Electron Tube Switches

One application of an electron tube switch that has proven superior to the electromechanical relay is in discontinuous speed switching circuits. A two-speed positional servomechanism must have a switching device that connects the output of either the coarse speed syncro or the fine speed syncro to the amplifier.

Shown in *Fig.* 3 is the basic element of such an electron tube switch. At low values of error signal, the neon tube will not conduct, and the servo system operates at the fine speed. When the error becomes excessive, the coarse error signal, modified by A_1 causes the neon tube to ignite. Since the

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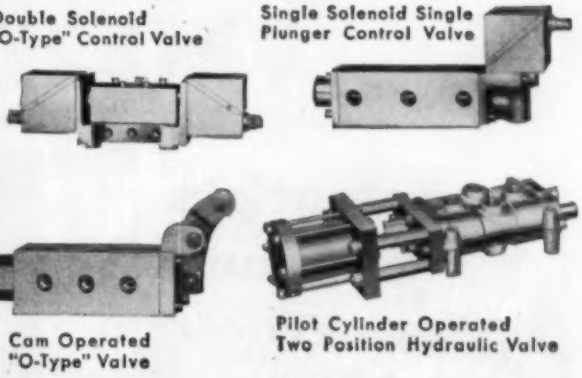
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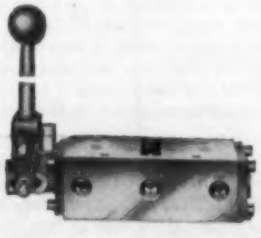

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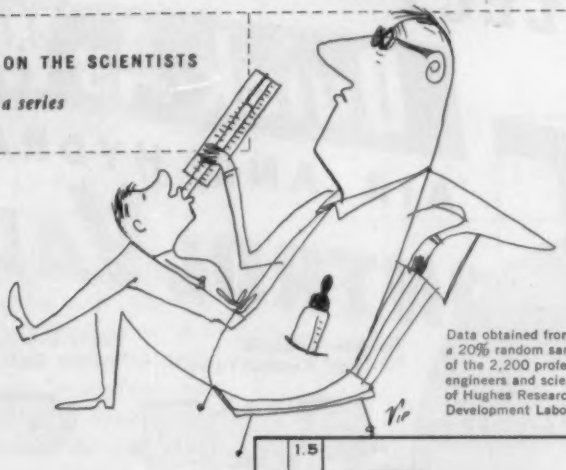
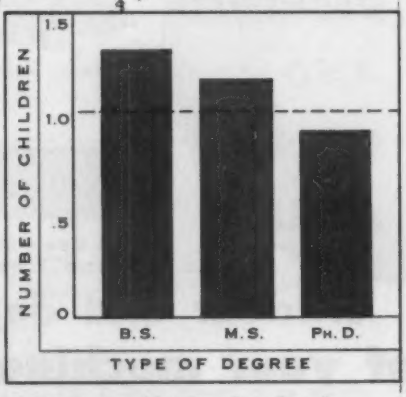
SIDELIGHTS ON THE SCIENTISTS

number **1** *of a series*



Data obtained from a 20% random sample of the 2,200 professional engineers and scientists of Hughes Research and Development Laboratories.



Scientists and Their Children

SOME OF THE YOUNG FELLOWS on our staff have been analyzing our files of personal data regarding scientists and engineers here at Hughes. What group characteristics would be found?

With additional facts cheerfully contributed by their colleagues they have come up with a score of relationships—some amusing, some quite surprising. We shall chart the most interesting results for you in this series.

Results may be to some extent atypical due to California locale. Yet we would surmise that they are fairly representative. Some may well lead to soul-searching: "How am *I* doing in my chosen field? In my projected career, am I near the point of optimum advancement, or am I just somewhere along the way?" If the time should come when a move is indicated in your case, we hope you will give serious consideration to joining the exceptional group at Hughes.

* * *

IN OUR LABORATORIES here at Hughes, more than half of the engineers and scientists have had one or more years of graduate work, one in four has his Master's, one in 15 his Doctor's. The professional level is being stepped up continually to insure our future success in commercial as well as military work.

Scientific Staff Relations

Security considerations have largely obscured Hughes' pre-eminence as a developer and manufacturer of airborne electronic systems. Hughes is now largest in the field. The Hughes research program is of wide variety and scope. It affords exceptional freedom as well as exceptional facilities. Indeed, it would be hard to find a more exciting and rewarding human climate for a career in science.

Our program includes military projects in ground and airborne electronics, guided missiles, automatic control, synthetic intelligence and precision mechanical engineering. Projects of broader commercial and scientific interest include research in semiconductors, electron tubes, digital and analog computation, data handling, navigation, production automation.

RIGHT NOW *we have positions for people familiar with transistor and digital computer techniques. Digital computers similar to the successful Hughes airborne fire control computers are being applied by the Ground Systems Department to the information processing and computing functions of the large ground radar weapons control systems. Engineers and physicists with experience in these fields, or with exceptional ability, are invited to send us their qualifications.*

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value of the resistor R_1 is high compared to the impedance of the transformer secondary, it acts as a voltage divider. The fine error signal is highly attenuated through the shorted neon tube, while the coarse error signal is channelled through the tube to the amplifier.

Askania of Germany first used this method on the V-2 rockets. It has the advantages of maximum sensitivity at low input levels, very long life, fast response, and an accurate switching zone. Since the VR tube is *On* only when the servo is operating on coarse speed, it indicates excessive error.

Electromechanical Switch

Circuit applications designed to utilize a chopper have become as varied as the engineers using them. The chopper has found widespread use in amplifying small dc signals. The vacuum tube modulator, magnetic modulator or other conventional dc amplifiers have zero drift or that characteristic which will result in an output voltage when no input signal is present. The chopper is entirely free from zero drift and when used in conjunction with an ac amplifier, a relatively stable system can result.

Usually the chopper is driven from the main supply voltage, and the most common frequencies are 60 cycles and 400 cycles. At 400 cycles, this switch must operate 1,440,000 times per hour. As 1000 hours is considered a reasonable life by some people, this becomes 1.44×10^9 operations. Needless to say, this is quite a number of operations for a relay and it is obvious that the question of life requires special attention.

Much work in the theories of wear, semiconduction, corrosion, and other solid state phenomena is badly needed throughout the industry at this time. Much good work is being done at universities and industrial laboratories on these life problems. Bibliography is growing and can be obtained by those interested.

From a paper entitled, "Switching Systems" presented at the Symposium on Electromagnetic Relays at Oklahoma A&M College, Stillwater, Okla., March 1955.

BRITISH INDUSTRY AND AUTOMATION

By FRANK G. WOOLLARD
Institution of Production Engineers
London, England

IN ORDER to see where automation is leading us, we need a plain, objective statement of the present situation. We must relegate Samuel Butler's *Erewhon,* Karel Capek's *Rossum's Universal Robots,* Huxley's *Brave New World,* and Chaplin's *Modern Times* to the place where they belong. And, if we are to assess the true relationship of automation in our lives, we must eliminate from our minds the emotional content engendered by such phrases as "seeing eyes," "automatic memories" and "electronic brains," so beloved of our journalistic friends.

Some writers on the theme of machines in control, particularly when they adopt these anthropomorphic similes, can be very alarming, and some are quite terrifying; but the fact is that their stories are just not true. Man remains, as always, in control of the machines he has created. He may wrongfully employ that control, but if he does, the fault will be due to his own actions and in no way due to the machine's. They will never be any other than his most dutiful servants.

If we look upon automatic transfer machines and automation as a logical outcome of the flow production system, the computer as a natural development of the Babbage calculating machine evolving upon a long series of office appliances, the numerical control system as an extension of the Jacquard apparatus for facilitating the weaving of figured textiles in the loom, it may help the realization that there is nothing sinister or frightening in this new system of producing goods.

The word "system" is used advisedly, for these methods are a marriage of mechanism and management in which management is the dominant partner. It is the bringing together by management of methods, mechanisms and self-acting controls which has made possible the conception of the auto-

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matic factory.

Moreover, we must recognize that automatic operation is not new. Many of our process plants have been subject to automatic operation and control, in whole or in part, for a long time—among them papermaking, printing, flour milling, chemical manufacture, petroleum products, food preparation; also individual automatic metalworking machines have been in existence for more than 50 years. What is new is the extension of automatic operation to the hard, heavy, awkward and unyielding shapes of those components used in industries which are based on engineering practice, the adoption of controls — electronic or otherwise—and the institution of feedback apparatus and servomechanisms to ensure that accuracy is maintained within predetermined limits.

It is, for many, something of a shock to see an automobile cylinder block "flowing" through all the many operations necessary to complete it for embodiment in a motor car, with the same apparent ease as the operation of filling and sealing bottles in a milk distribution center. It is, of course, the in-line transfer machine, coupled with interoperation transfer mechanisms, that have so much caught the imagination, because these, associated with automatic assembly, would make it appear that the automatic factory, or ultimate automation as the Americans have called it, is just around the corner.

Is it true that ultimate automation will be achieved in the next decade? If we mean by this term a factory entirely without machine operators, the answer is probably in the negative. Automation will only be adopted when there is economic justification for such a course. The economic reasons may not, it is true, be dictated by monetary considerations only; there may be a shortage of labor; the tasks may be too heavy for the operators or they may be dangerous to health or inimical to life or limbs. These possibilities nonetheless must be classed as economic considerations in the circumstances that we are considering. There are, in all factories, a considerable number of tasks which

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can be more economically handled by manual labor.

Advantages of Automation

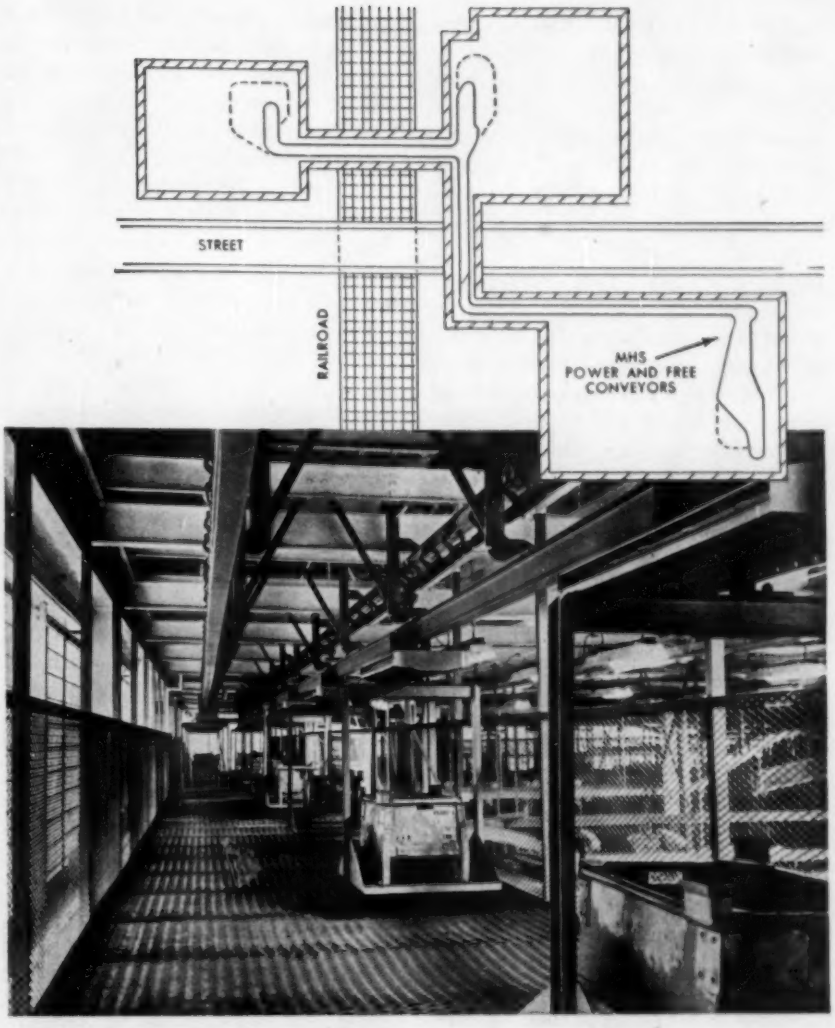
This brings us to the question—why do we adopt automation—what do we gain? The answer is:

1. Considerable saving of direct labor.
2. Greater economy in floor space.
3. Lower inventory of work in progress.
4. Greater control of processing.
5. Cheaper operating heads on the machines.
6. Automatic inspection of the workpiece.
7. Fuller utilization of machine capacity.

It is the last of these wherein the greatest economy lies. For the past century we have been striving to improve the effectiveness of cutting tools and in the last 25 years the advances in this direction have been phenomenal. Based on high-speed steel in the 1930's, the modern carbide tools are showing improvements in the order of 450 to 875 per cent. Yet until the advent of the automatic transfer machine little had been done, mechanically, to expedite the loading and unloading of workpieces into machines.

Now, with automatic transfer and automation, this part of the operation is as near 100 per cent efficient as it is ever likely to be. One authority states that operations performed at 65 per cent of the rated capacity of the machines have, after the application of automation, been raised to 80 per cent, but this is probably a low estimate, since there are many instances of increases of as much as 100 per cent to 650 per cent in labor saving, from which it would appear that the machine capacity must have been very greatly increased, as well as the interoperational handling.

Moreover, machine control units fitted with toolometers, i.e., devices for giving warning when tools should be changed, are reducing the downtime for this operation to a minimum, while interoperational stocks carried in self-moving storage ensure the maximum continuity of operation. Automatic inspection which is now being in-



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troduced and which will exercise control by means of feedback devices, will not only provide greater control, but will also ensure that processing is continuous to completion and will still further reduce the inventory of work in process.

Economy in floor space may represent a saving of 25 per cent to 50 per cent. The economy in the manufacture of machine heads is not, strictly, due to the adoption of transfer machines. Such simplification of the machines could have been carried out under any system of manufacture, but the advent of automatic transfer machines led to rethinking on the part of machine tool designers with this satisfactory result.

Effect on Management

To deal first with the intramural situation, it would appear that management in all its phases will have to be more thorough, more co-operative and more communicative. This is not intended as a reflection on present-day management, which is, for the most part, both efficient and effective for present conditions. It simply means that the new circumstances will necessitate a new appraisal of certain management functions in the automatic factory. It will, for instance, be absolutely essential that all preparatory work should be more thorough, and this will apply to every item, from market research to the testing of prototypes. Nothing can be left to chance or allowed to remain in abeyance when the whole factory is so closely integrated and keyed to a higher tempo than ever before. In brief, all preliminaries of every sort must, to use a familiar phrase, be "signed, sealed and settled" before the job is launched.

In the automatic factory managers will, of necessity, have to become more co-operative and more imaginative in their co-operation. There will be a need for closer team work both up and down the executive and across the functional lines of the organization. The gift of prophecy will be a near essential, for it will be important that all possible difficulties shall be foreseen; that, in fact, as far as is humanly possible, all action shall be the outcome of anticipation rather than adjustments arising out of default.

Management will have to be more communicative. Instructions will need to be more fully considered, less tentative, more explicit and positive, than hitherto. Transmission of communications will need to be quicker. Radio will be pressed into service. Television is already being used here as well as in the U. S. A. as a means of assisting works communications.

The foregoing may conjure up visions of "big brother" shouting his instructions from the head office. If so, I have conveyed an entirely wrong impression. The organization will need to be segmented according to its several functions, with executive leaders for every segment—it is between these that the swift communication and the instant co-operation will be required. Such requirements will demand a real esprit de corps—not merely lip service—in which everyone respects the other and each will cheerfully take more than his share of work when necessary.

It will be essential to convince supervisors and work people that the company's aims are worthy, that the methods they adopt are necessary and that the machinery will function as intended. These ideas must become articles of faith among the staff if the full reward is to be reaped. Such esprit de corps is desirable in any company, but nowhere more so than in the automatic factory of tomorrow. Incidentally, I am told that selling automation to existing supervisory staffs is much more difficult than convincing the shop floor worker that it is desirable.

Is Automation a Blessing?

We should ask, "Is machinery beneficial or inimical to mankind?" Linked with this is the query, "Is the factory system opposed to the interests of mankind?" These questions have been asked time and again, and we must endeavor to answer them, because automation can exist only in the factory and it is dependent on the continual improvement of machinery. For the production engineer there would appear to be only one answer; but production engineers are apt to be biased.

It is no exaggeration to say that, but for machine power, slavery might still exist. It must be recognized that the abolition of slavery (1833 in the British Colonies and 1863 in the United States), was largely due to the invention of the rotative steam engine in 1783. Its rapid development in the succeeding years challenged the economic, as well as the moral, justification for the use of slave labor.

The New Era

With the aid of automation, I am of the opinion that we shall enter a new phase of fine living. You may be inclined to regard me as a starry-eyed optimist, but when I look back to the beginning of the Industrial Revolution—even when I look back to my own youth—I am convinced that my optimism is justified.

Today our factory lasses are neatly coiffured and well shod. In dress they differ little, if any, from their middle class sisters; in fact they are the new middle class. They wear silk stockings finer than those available to Good Queen Bess. Their families can hear music that, less than 50 years ago, was denied even to kings. The theatre is brought to their homes for an annual payment of less than the cost of one box at the live theatre. Light and heat are both available at the touch of a switch and water is on tap (one of the first steps in automation). It is true that all this does not apply to all rural districts, but they are not being forgotten. What great changes we have seen and what greater and better changes are in store for us—if some madman doesn't blow us all up with nuclear weapons. Yes, I admit that progress brings its dangers but, so far, mankind, as a whole, has survived and has prospered.

From a paper entitled, "Machines in the Service of Man" presented at the Automatic Factory Conference of the Institution of Production Engineers in Margate, England, June 1955.